PULVERISED OIL PALM WOOD (*ELAEIS GUINEENSIS)* IN CLAY BODY AND COST EFFECTS IN CERAMIC FIRING

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Abstract

The use of Pulverized Oil Palm Wood (POPW) in clay body as an augmented or alternative heat energy source is considered in this paper because of the rising cost of liquefied gas. An experiment was conducted blending POPW in the ratios of 10:90, 80:20, 30:70, 40:60, 50:50, POPW to an adopted claybody for ceramic firing. The firing ranges were from 650^{o}c, 750, 850, 950, 1050 to 1240 ^{o}c. oxidation atmosphere. Another firing was done using only liquefied gas and yet another with POPW augmented with liquefied gas. Mean and Standard deviation were used to test the research questions and independent t-test was used to analyse the data collected in the experiments. Result showed that the firing with liquid gas only was more expensive than the other two at any temperature. This method of firing cuts down on cost of firing and is recommended for industries in the ceramic profession.

Keywords: *Pulverized Oil Palm Wood (POPW), Wood In Clay, Augmentation, Ceramic Firing Cast.*

Introduction

Energy for firing ceramics could be argued as one of the factors to be considered in Ceramic production. Electricity, oil, coal, wood and liquefied gas were sources that generated energy for heat during the process of changing greenware to ceramic, a finish product of the ceramics works. According to Zakin (1990:228) and Effiom (2000:120-123), ceramic is greenware made permanent by firing. Cardew (1971:45) maintained that clay ware does not have any commercial value no matter how much craftsmanship is put into its making until it has been fired. Similarly Andeval (2006:6) submitted that this is the problem potters have and will face through the ages. The energy source for firing is the concern of this paper. An experiment was thus conducted with Pulverized Oil Palm Wood, POPW (*Elaeis Guineensis)* added to an adopted claybody (Wood in Clay) as innovation from wood on the claybody. The effects are worthy of note.

The main aim was to include organic fuel source (POPW) in clay body for energy production experiences during firing. The objective was to determine the effects of POPW in claybody on cost of fuel consumption in ceramic firing. To realize the set objective, the research sought answers to the following questions :

(1) Is there any significant effects of POPW in claybody on heat energy generation in ceramic firing?

(2) Can the outcome reduce the cost of the fuel used?

A null hypothesis was developed to generate a basis for the study that:

(1) There is no significant effect at ($\pm$ 0.05 level) of Pulverized Oil Palm Wood in clay body on fuel consumption cost in ceramic firing

The rationale of the study is that it will unfold to industries and ceramists that the use of POPW can release enough energy for firing. It will create a cheaper source of energy as its combined effects with liquefied gas can improve ceramics even in material use, cost and time. As this paper is particularly concerned with innovating the material for firing, costwise, it will empower our young school leavers to use these materials in cheap but valuable production.

Materials in the Experiment

The principal material to be used in the study were delimited to Oil Palm Wood and claybody adopted from Akwa Ibom State of Nigeria and analysed in the department of Soil Science, University of Uyo (see table 1).

Table 1: Analysis of oil palm wood before experiment (wt %).

Element	**Al_2O_3**	**SiO_2**	**FeO**	**$Fe2O_3$**	**Ca**	**K**	**Na**	**Mg**	**Sn**	**Pb**	**Co**	**Cr**	**Mn**	**C**
Quantity	4	15	0.20	0.36	0.01	0.01	0.12	0.05	<0.01	<0.01	<0.01	<0.01	0.20	80.1

Table 3.2: Analysis of clay body before experiment (wt %).

Element	Al_2O_3	SiO_2	K_2O	Na_2O	CaO	PbO	Fe_2O	MgO	Sn	Co	B	Cr	Mn
Adopted Clay body (ED – I)	20	76	1.01	1.82	0.04	0.05	0.57	<0.01	<0.01	<0.01	<0.01	<0.01	0.22

These materials were abundant and readily available in Akwa Ibom State Nigeria (Ndon 2006:15). The use of these materials would have caused problems of deforestation found in (earth & mother, 2010, Awake April 2010:18), but it is solved by the fact that oil palm trees with a life span of fifty years, naturally fall down or are cut down after their yielding period is over. This is done for safety and replacement by new species. In studies conducted by Ali, Alimed and Ahuawan (2008:137-143), Clark (1964), Udom (2007), Ekong (2008), it is maintained that the incorporation of other materials other than clay into claybody, would change the face of pottery. Another additive expert as reported in active-mineral (2011) claimed that acti-gel 208 lowers the cost and improves ceramic glaze and body formulation. This paper believes that most organic matter are energy base which and could be released if properly harnessed.

The theories of conservation of energy by Einstein confirms that chemical energy stored in the palm stem when burnt could be converted into heat energy used in the firing. The use of oxygen was to support combustion as noted by Bechas even in 1667 (Sharma and Sharma 2005:169-183), Simpson (2004:21-25)

An experiment carried out by Zakin (1990:7) indicated that percentages of clay for successful clay bodies were as follows:

1. high clay percentage clay bodies = clay 90% and non-clay material 10%
2. medium clay percentage clay bodies = 60% and non- clay material 40%
3. low clay percentage clay bodies = 50% and non- clay- materials 50%

Zakin's pie chart recommended the correct clay body composition for a successful firing. Therefore the percentage of additives to make an effective clay body was guided by Zakin's work:

Material Preparation

The oil palm wood stem of 20 kg collected was ground in ordinary grinder then ball-milled wet for 12 hours to pass through 100 Bs mesh sieve. The ball-milled POPW was mixed with slaked clay as indicated in (The composition 3.9.2). This was to ensure a homogeneous mixture with the clay body itself. The composition achieved was allowed as paste to stand for two weeks for ageing so as to increase plasticity.

The composition

The adopted oil palm wood formed the specimen that was added to the controlled clay body (Ebes), in the proportion of 10%, 20%, 30%, 40% and 50%. To have enough of each representation of these batches for at least ten (10) pieces according to Essien (1997:120), it became necessary to take the following steps:

i. To prepare 10% oil palm stem wood to 90% clay body, 10%: 200gms of ground oil palm wood samples was added to 90%, that is, 1,800 grams clay body to form a total of 2kg (2000 grams) of specimen 1. Specimen was mixed in enough water to form slurry, allowing overnight for fermentation. It was ball-milled for twelve hours, sieved through 100 mesh. The slurry was dried to paste ready for use.

ii. The process was repeated to specimen 2, that was, 20% (400g) oil palm sample with 80% (1,600g) clay body to form a total of 2kg (2000g).

iii. The process was repeated to specimen 3, that was, 30% (600g) oil palm sample with 70% (1,400g) clay body, totaling 2kg (2000g).

iv. The process was repeated to specimen 4, that was, 40% (800g) oil palm sample with 60% (1,200g) clay body, totaling 2kg (2000g).

v. The process was repeated to specimen 5, that was, 50% (1000g) oil palm sample with 50% (1,000g) clay body, totaling 2kg (2000g). The figures were recorded in table 4.1.

Design and Production

The size of the dice needed for the experiment was (12 x 4 x 1.5) cm^3. This was to ensure suitability for the experiment. It was produced by pressing method of one bar of pressure in metal mould at a bread dough paste state. Similar method of production was applied to the entire specimens which were identified and kept for one week to air dry for firing. In drying out it was necessary to keep them flat between moderate load of paper to ensure flattened surface.

Loading and Firing:

Enough amount of each percentage level (10 – 50)% wt progression of pulverized oil palm wood was loaded for each batch of firing. The pyrometric Orton cone levels, 022 to 9, for firing maturity reliability, were laid together with the specimens in the kiln. Hamer's specification in the table of incandescence also applied to confirm the kiln interior glow (Hamer, 1977:344) at the end of exhaustible combustion temperature of each specimen, the group temperature was recorded and the firing stopped. These were based on 650^{o}C, 700^{o}C, 800^{o}C, 900^{o}C and 1050 while the limit for liquefied gas was 1220^{o}C maximum temperature. Having recorded the data that would help test for different effects as required in the objectives, the researcher shut off the kiln and allowed it to cool to room temperature before unloading finally. This was for kiln safety.

Determination of the Cost of Firing for Ceramic Piece.

Experiment 1 Stage 1 Specimen: Control

100% Ebe's clay body without POPW was fired traditionally with gas to cone 6 equivalent to 1230^{o}C and cooled to ambient temperature. The cost of the quantity of gas used for firing was recorded; three observations were made and the average calculated and recorded in Table 3.

Cost of gas utilized = ₦8,657.30

Experiment 1 Stage 2 Specimen 1

90% Ebe's clay body blended with 10% POPW was fired to exhaustible heat energy level 650^{o}C and cooled to ambient temperature. The cost of firing with air only was recorded, three observations were made and the average recorded in Table 3.

Experiment 1 Stage 2 Specimens 2, 3, 4 and 5.

Experiment 1, stage 2, specimen 1 was repeated for 2, 3, 4 and 5 to their exhaustible heat energy level respectively. Each of their three mean cost readings of firing with air only was calculated and recorded in Table 3.

Experiment 1 stage 3 specimen 1: Experiment 1, stage 2, specimen 1 was repeated but at exhaustible heat energy level. The mean costs of, firing with air and gas augmented to cone 6 equivalent, 1230^{o}C, was recorded in Table 3.

Experiment 1 stage 3 specimens 2, 3, 4 and 5. Experiment 1, stage 3, specimen 1 was repeated for 2, 3, 4 and 5. Each of the mean cost of, firing with air and gas augmented to cone 6, which is equivalent to a temperature of 1230^{o}C was calculated, and recorded in Table 3. The data were presented, analysed and findings discussed.

Cost of firing the ceramic bodies:

Fuel cost as suggested by Cardew (1971:149), Clark (1968:15), Umar Oke and (2007:101 –108), Horner and Al-Hajj (1998:459 – 470) was determined as the suitable clay body was prepared, the most economical fuel source was used and air tight kiln ensured a successful firing. Then all integral factors were noted and a summation of cost resulted in the calculation of fuel cost (Horner and Al-Hajj 1998:459 – 470. In the case of this work, the effects of Pulverized oil palm wood in clay body on fuel consumption in ceramic firing applied, whereby pulverized oil palm wood in clay body started the firing, then it was augmented with gas and calculation made. That is, cost of wood and air in addition to cost of gas used for augmentation which gave the total cost of firing. In the system of production, a good combustion system perfected greater product quality, temperature uniformity, system flexibility, efficiency, dependability, increased productivity and reasonable return on investment.

Method of Data Analysis

The purpose of this research was to determine the effects of (10 – 50)% weight of pulverized oil palm *Elaeis guineensis* wood (POPW) in clay body and fuel consumption in ceramic firing. Experiments were conducted, data obtained and the analysis done, using mean and standard deviation for research questions and t-test for the hypothesis as shown in the following tables

In returning to answer the research question asked earlier, whether there are any significant effects of pulverized oil palm POPW in clay body on heat generated and cost in ceramic firing?

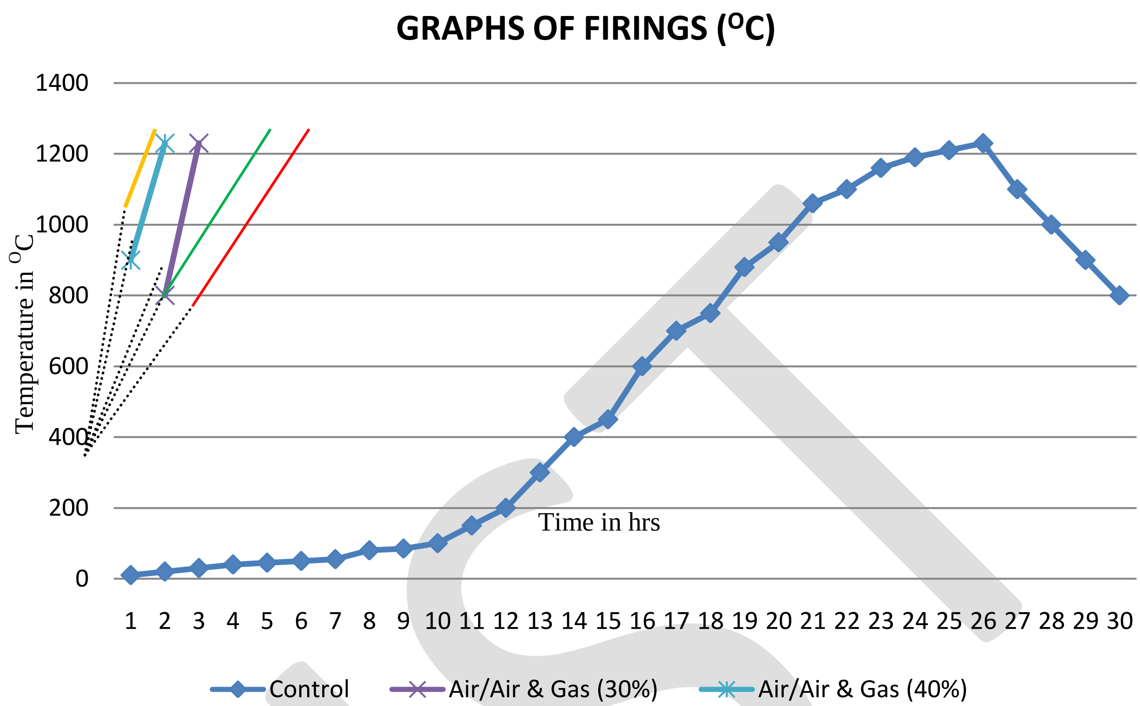

Figure 1*:* *Control for check*

Entries in Table 3 show greater mean of 3553.20 and lower mean of 932.30 for clay body energy cost in firing with air and liquefied gas, and air only respectively. The standard deviations of 1100.387 and 111.840 show the variability of each score from the mean. The result revealed that clay body firing cost fired with air and liquefied gas is greater than the clay body firing cost fired with air only. This result is further demonstrated in Figure 2

The graphic presentation revealed that the estimated marginal mean for firing with liquefied gas and air, and air only was increasing across the composition levels, but greater at firing with air and liquefied gas than with air only.

Table 3: The Effects of pulverized oil palm wood (POPW) in clay body on fuel consumption cost in ceramic firing

Specimen	Clay Body Composition in %		Fuel Consumption cost firing with Air only		Fuel Consumption Cost firing with Air and Gas to Cone 6 ≡ 1230°c		Fuel Consumption Test firing to Cone 6 ≡ 1230°c with Gas only
	Ebe's clay body	POPW		COST ₦	-	COST ₦	COST ₦
Control	100	0		_____		____	8,657.30
1	90	10	Δ 022 ≡ 650°C	1,080.00	Δ 6 ≡ 1240°C	4,812.80	
2	80	20	Δ 019 ≡ 700°C	984,90	Δ 6 ≡ 1230°C	4,317.70	
3	70	30	Δ 019 ≡ 800°C	886,60	Δ 6 ≡ 1230°C	3,386.20	
4	60	40	Δ 012 ≡ 900°C	788,30	Δ 6 ≡ 1220°C	2,871.30	
5	50	50	Δ 04 ≡ 1050°C	903,30	Δ 6 ≡ 1215°C	2,158.10	
Calculated mean:	x	=		932.30	:	3533.20	
Standard deviation:	std	=		111.84	:	1100.39	

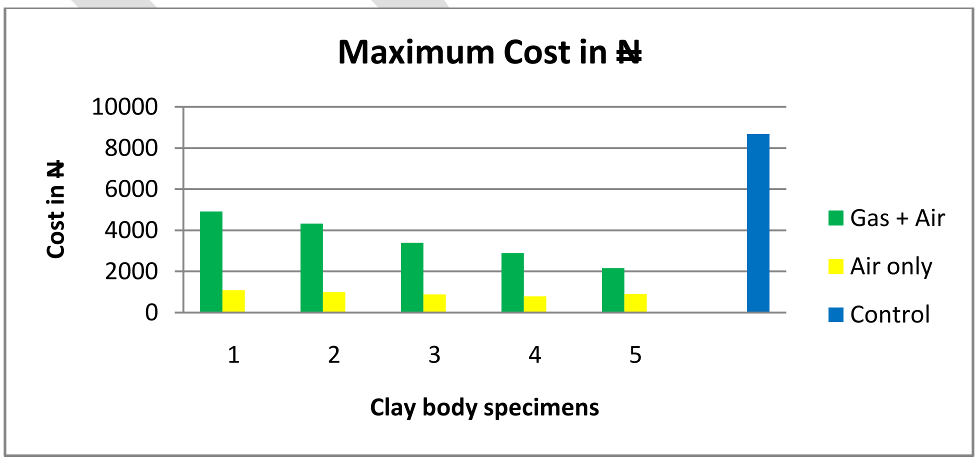

***Figure 2: Maximum Cost In ₦ of Fuel Consumption in Ebe's Clay Body And POPW Composition, 1 To 5 in Ceramic Firing*.**

Table 4: Summary of the effects of POPW in clay body on fuel consumption cost in ceramic firing

Variable	Firing	N	Mean	Std deviation	df	t-cal	t-crit
Fuel consumption cost	With Air only	5	932.30	111.840			
					8		2.309
	With Air and liquefied gas	5	3533.20	1100.387		-5.258	

**** Significant at 0.05 level of significance***

Table 4 showed that the calculated t-value of -5.258 was greater than the critical t-value of 2.309 at five percent(.05%) level of significance. The result is significant; therefore, the hypothesis that there are no significant effects of the POPW in clay body fuel consumption on ceramic firing is rejected. The result means that POPW in clay body reduces the fuel consumption cost on ceramic firing.

Therefore the hypothesis that there is no significant effect of pulverized oil palm wood (POPW) in clay body on fuel consumption cost in ceramic firing is rejected.

Findings

From the firing analysis in Table 3, it could be seen that the total cost of each complete firing is as follows:

1. The use of gas is more expensive than the use of POPW
2. The use of POPW in firing is less expensive than the use of gas
3. Augmenting POPW with gas reduces the cost.
4. Low firing of pulverized clay body is less expensive as shown in Table 1.

Cost

From Fig 2, findings show that while the traditional ceramic gas fuel firing cost is ₦8,6587.300, the mean POPW + air fuel firing cost is ₦3,533.200.

The difference in cost is ₦5,124.10

Advantage POPW + air + gas fuel cost to gas alone control. The mean POPW + air fuel firing cost is ₦932.30. The difference in cost is ₦7,725.0. Advantage POPW + air only fuel cost to gas alone of control and ₦4,191.80 advantage POPW + air only fuel cost to POPW + air + gas.

This means that using POPW with air to fire saves money, especially, when the stipulated average temperatures required are in the low ranges like: 650^{o}C to 1050^{o}C. Using POPW augmented with gas still saves more than the cost using the traditional petroleum gas alone.

Conclusion

In conclusion, the research has taken into consideration the objectives, and the seven null hypotheses formulated to guide this study were rejected. Also considered were the findings related to the problems the research had posed, that is, finding a way of solving energy problems by utilizing the neglected raw materials like the wood of felled oil palm trees in ceramic firings in Nigeria. It has considered the way of adapting the firing process in a convenient modern method. It has considered the outcome of combination of wood and gas. It has also considered the way the effects of the POPW has on the extraneous variables, the acceptability of the effects on the society's utilising efficiency, the contribution it will have on ceramic profession, above all, the possibility of not only creating job but retaining the establishment that creates the jobs for sustenance. This is expected as the results of findings in heat conservation, shrinkage advantage manipulations, improvements in crushing strength, and control of water absorption have been unfolded in the research. The control of the weight and volume of the ceramic piece; and above all the reduction of the cost of fuel consumption in ceramic firing is interesting. This work has introduced a new cheaper method of firing ceramic wares by utilizing energy source (wood) directly in clay to formulate wood-in-clay green wares before firing with gas as against the usual firing by wood-on- clay method. The researcher is poised to conclude that the research points a way to a better future for the Ceramics Industry and Nigeria energy utilisation.

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