LAUTECH Journal of Engineering and Technology 8(2)2014: 79 - 83

QUANTIFYING HEAT AND POWER GENERATION FROM PALM KERNEL SHELL AND PALM FRUIT FIBRE

Joseph Adama and Mathew Okara

Department of Agricultural and Bioresources Engineering,
Michael Okpara University of Agriculture, Umudike – Nigeria

ABSTRACT

Considerable quantities of palm kernel shell (PKS) and palm fruit fibre (PFF) are produced as by-products of palm fruits processing. These by-products are long regarded as wastes. Indeed, there are wastes. Now, research has shown that they are not wastes as such but very important resources which are out of use.

The objective of this study is to quantify the heat and power generated from palm kernel shell (PKS) and palm fruit fibre (PFF). Samples of PKS and PFF (Dura and Pisifera varieties) at varying quantities were collected from a palm fruits processing mill and combusted inside the oven. The experiment was conducted in an oil mill located at Amaokwe Item in Abia state Nigeria. The mill has a capacity of processing 60 tons of palm fruits per day. Parameters measured directly are; current, induced voltage, pressure, time and the quantity of fuels burned. Parameters calculated are the electrical power, heat energy and ratio of PKS to PFF mixed. The current was measured using ammeter and the voltage was measured using a voltmeter. The pressure was measured using pressure gauge which was attached to the boiler. The initial and final temperatures were measured using a DT9205A thermocouple. Results show that at 50 bars, maximum current of 5.0A and voltage of 210V were recorded. The calculated electrical power of 1050W was obtained. The ratio of PKS to PFF at these readings was 4:1 and the heat generated at these conditions was 110523.3kJ. The power generated can power 3 refrigerators of 100W capacity and 12 bulbs of 60W capacity each all at the same time. It is concluded that palm kernel shell and palm fruits fibre are capable of replacing fossil fuel in palm fruit processing and electricity generation.

INTRODUCTION

Oil palm is known to have originated from the tropical Rainforest zone of West Africa, but has spread to most of the equatorial tropics of South-East Asia and America (Hartley, 1988; Luangkiattikhum et al.; 2008). In palm fruits processing for palm oil and palm kernel oil production, palm fruit fibre, effluent, kernel shell and empty fruit bunch are the by-products of production operation. About 0.07 tons of palm kernel shell, 0.103 tons of palm fruits fibre and 0.012 tons of kernels are produced as solid wastes for every ton of oil palm fruit bunch being fed into the palm oil processing plant (Luangklattikhun et al; 2008; Pansamut et al.; 2003). The amount of each component waste generated from palm oil and palm kernel oil processing is dependent on the oil palm species dominant in the quantity being processed. The major consideration and utilization of palm kernel shell has been for energy production through direct combustion processes. Palm kernel shell can also be converted to biogas through thermo-chemical process of biomass conversion. Palm kernel shell and fibre, as good energy sources, can be combined together in a certain ratio to power the boiler and run oil mill plants (Pickard, 2005; Perez, 1997). It is estimated that in 2003, Malaysian palm oil mills generated nearly 300 MW of electricity from its palm oil processing by-products, mainly from shells and fibres. This revelation tries to conclude that palm kernel shells and palm fruits fibre could be sources of renewable energy fuels for the future.

Power generation has been a serious problem in the world over especially in the developing world. In Nigeria for instance, only about 55.2% of the entire country was electrified and average household enjoyed electricity for only 8 hours per day in 2005, (NBS, 2006). The state of Nigerian power generation system is poor. The conventional systems of power generation such as hydro, nuclear, gas, thermal etc are known to be costly and irregular

Petroleum products which offer viable alternative to conventional source of power for processing operation have been known to be scarce and too costly far above the financial reach of ordinary processors in Nigeria. Studies show that power has been one of the greatest contraints to the manufacturing industry in Nigeria (RMRDC, 2006 and 2009).

The environmental hazards of generating plants are enormous Also palm kernel shell and palm fruits fibre dumped in many places as wastes have caused environmental pollution. These conditions call for studies to find alternative energy sources for our processing industries as well as ways of utilizing the excess wastes from palm fruits processing. Such alternative energy sources must be clean, readily available and affordable. Wastes from palm fruits processing mills could be enviable alternative. The objective of this study is to quantify heat and power generation from palm kernel shells and palm fruits fibre

MATERIALS AND METHODS

Description of the Project Area

The project area for this research is located at Amaokwe Item in Bende Local Government Area of Abia State Nigeria. The name of the farm is Pioneer Oil Mill Ltd. The farm was established by the government of Eastern region to serve the rural farmers. In 1969 the farm was abandoned by the government for a period of 30 years. It was later renovated in 1999, and now being managed by Agu Ojukwu from Amaokwe Item. The farm has an integrated oil palm mill which occupies 0.3 ha of the farm. The oil palms (palm fruits) provide some raw materials for the mill. Other raw materials for processing in the mill are being provided by rural women.

The oil mill

The oil mill was the major equipment used to obtain data for this research. It has a capacity of handling 60 tons of boiled palm fruit /day. It is is made up of the following components: the boiler, the steam engine, the alternator/generator, the central pulley system, the centrifugal press, the digester, the sterilizer and the kernel separator. The mill is not dependent on power from Power Holding Company of Nigeria. It utilizes energy from palm kernel shell and palm fruit fibre mixed at various ratios to produce the energy needed to power the mill and generate electricity for other uses in the farm.

Various quantities of palm kernel shell (Dura and Pisiferal) and fibre are being combusted continuously in the oven. The combustion process brings about heat generation which in turn heats the water inside the boiler by conduction. The water boils and produces steam. The steam travels through a vessel which runs from the boiler to the steam engine. Part of the steam goes to the sterilizer. The steam engine uses the steam as a working fluid thereby converting the heat energy to useful mechanical energy.

Power is transmitted from the steam engine to the central pulley system which in turn powers the other components of the mill (digester, kernel separator and centrifugal press) and the alternator/generator which produces electricity.

Measurements and Instrumentation

The parameters measured in the mill are, the current generated, the induced voltage, the temperature, the pressure and the elapsed time.

The Current

The current was measured using ammeter rated 0-20A of make DT9205A procured from the market. The ammeter was connected in series (Figure 1). The line wire (L) and the neutral wire (N) were first identified. The line wire was then connected to one terminal of the alternator and another wire runs from the other terminal to the load. The neutral wire runs from the alternator directly to the load. The type of ammeter used was determined based on the capacity and voltage of the alternator.

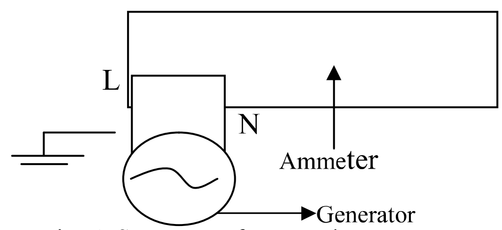

Fig. 1 Sequence of connecting ammeter to a generator

The Induced Voltage

The voltage was measured using multi-meter that can measure the AC and DC voltages as well as the DC current. The voltage is digital and has a rating of 0-1000V. It system was connected in parallel. The readings were displayed on the screen. One terminal of the multi-meter was connected to the line wire of the alternator and another goes to the neutral wire.

The Pressure Generated

The pressure generated was measured using a pressure gauge installed on the boiler. The different pressures were generated with continuous combustion of palm kernel shell and fibre.

The Elapsed Time

The elapsed time was measured with a stop watch in a Tecno phone (tecno p3 2.3.5, Android version). The elapsed time is the time taken for each loading of palm kernel shell and fibre to attain its maximum temperature.

Quantities of the Kernel Shell and Palm Fruits Fibre Combusted

The mass of the fuels were measured using the precision balance which has a capacity of 10 kg and a reading accuracy of 0.01kg.

The Temperature

The temperature was measured using a k-type thermo couple which uses Nikel alloy wires, one made of Chroma alloy and the other Alumel as shown in figure 3.2. It is then connected to an XMTD-2001 temperature controller, which was gotten from the Department of Electrical and Electronics Engineering, Michael Okpara University of Agriculture Umudike. The hot junction was wholly immersed in the oven to ensure accuracy.

Parameters Calculated

The following parameters were calculated from the measured parameters, heat and electric power.

Heat

The heat generated was calculated at different intervals based on the different quantities of kernel shell and fruit fibre combusted inside the oven. It was calculated using the equation of heat.

$$H = (M_1C_1 + M_2C_2)T_2\text{-}T_1 \quad (1)$$

Where:

H = Heat generated at different intervals of time (kJ), M_1 = Mass of palm kernel shell (kg) and M_2 = Mass of palm fruit fibre (kg)

C_1 = Specific heat capacity of palm kernel shell (3.1kJ/kg K)

C_2 = Specific heat capacity of palm fruit fibre (3.2kJ/kg K)

Electric Power

The electric power was also calculated at different time intervals as the PKS and PFF are combusted in the oven. The electric power was calculated using the formular

$$P = IV \quad (2)$$

Where;

P = Electric Power generated (W), I = current (A) and V = induced Voltage (V)

RESULTS AND DISCUSSION

The Current and Induced Voltage Generated at Varying Quantities of PKS and PFF during Idling and Operating Conditions.

Table 2 gives the current and induced voltage generated at varying quantities of PKS and PFF during idling and operating conditions. From the table, the initial mixture of PKS and PFF were 25kg and 27kg (at a ratio of 1:1.1) respectively. This is probably because the pressure generated had not reached the minimum pressure required to energize the steam engine. At 106 kg of PKS and 90 kg of PFF, current of 2.25A and a voltage of 132 V were recorded during idling (no loading), and a current of 0.01A and a voltage of 0.05V were recorded during operation (loaded). As more fuels are burnt, there were increases (up to a point) in current and voltage recorded. The maximum current and voltage were recorded at combustion of 164 kg of PKS and 131 kg of PFF. At these conditions, a current of 5.A and voltage of 210V were recorded during idling. When loaded, the current was 0.26A and the voltage was 5.5V.

Table 2: The Current and Induced Voltage Generated at varying Quantities of PKS and PFF during Idling and Operating Conditions from a Palm Oil Processing Plant

S/N	PKS (Kg)	PFF (kg)	Ratio	Current Generated (A)		Induced Voltage (V)	
				Idling	Operating condition	Idling	Operating condition
1	25	27	1:1.1	-	-	-	-
2	30	40	1:2.6	-	-	-	-
3	43	49	1.4:1	-	-	-	-
4	69	62	2:1	-	-	-	-
5	90	78	1.3:1	-	-	-	-
6	106	90	1.3:1	2.25	0.01	132	0.05
7	114	95	1.6:1	3.65	0.01	158	0.06
8	119	100	1:1	4.5	0.03	192	0.07
9	127	107	1.1:1	4.79	0.04	206	0.09
10	135	124	1:2.1	4.79	0.04	206	0.09
11	164	131	4.1:1	5.0	0.26	210	5.5

The Pressure, Initial and Final Temperatures Generated at Varying Quantities of PKS and PFF in a Steam Boiler

Table 3 gives the pressure, initial and final temperatures generated at varying quantities of PKS and PFF. From the table, the initial mixture of 25kg and 27kg of PKS and PFF respectively did not generate any pressure at a temperature of 206°C in 20 minutes. As more PKS and PFF were burnt, marginal rise in pressure of 2 bars was recorded at a temperature of 278°C. As in the case of current and voltage measurements, maximum pressure of

50 bars was recorded at combustion of 164 kg of PKS and 131 kg of PFF. The temperature at this condition was 870°C and the time taken was 2 hours 39 minutes.

Table 3: Pressure, Initial and Final Temperatures Generated at Varying Quantities of PKS and PFF in the Steam Boiler

S/N	PKS (kg)	PFF (kg)	Ratio	Pressure (bars)	Initial Temp (°C)	Final Temp (°C)	Time (mins)
1	25	27	1:1.1	0	30	206	20.00
2	30	40	1:2.6	0	206	278	7.10
3	43	49	1.4:1	2	278	365	10.30
4	69	62	2:1	7	365	519	20.24
5	90	78	1.3:1	15	519	667	17.20
6	106	90	1.3.1	25	667	778	15.00
7	114	95	1.6.1	32	728	775	6.20
8	119	100	1:1	38	715	783	3.20
9	127	107	1.1:1	40	733	788	6.10
10	135	124	1:2.1	40	749	820	7.30
11	164	131	4.1:1	50	750	870	30.00

The Heat and Electrical Power Calculated at Varying Quantities of PKS and PFF

Table 4 gives the heat and electrical power calculated at varying quantities of PKS and PFF. From the table, at initial mixture of 25kg and 27kg of PKS and PFF respectively; 28846.4kJ of heat was obtained but no electrical power was produced (as there was no current and induced voltage) at both idling and loaded conditions. As more of the materials are burnt, the quantity of heat produced continued to increase until the peak value is reached. As in the cases discussed above, the peak value was reached when 164 kg of PKS and 131 kg of PFF were burnt. At this condition also, maximum electrical power was generated. The heat produced at this point as calculated was110523.3 kJ and the electric power calculated 1050W.

The electric power generated can in addition to driving the components of the mill, powers 17 bulbs of 60W each, 3 refrigerators of 100W rating

Table 4:The Heat and Electrical Power Generated at Varying Quantities of PKS and PFF in a Palm Oil Processing Plant

S/N	PKS (Kg)	PFF (kg)	Ratio of mixture	Electrical power (W)		Heat (KJ)
				Idling	Operating Condition	
1	25	27	1:1.1	-	-	28846.4
2	30	40	1:2.6	-	-	32957.6
3	43	49	1.4:1	-	-	3896 9.3
4	69	62	2:1	-	-	57788.1
5	90	78	1.3:1	-	-	75000.5
6	106	90	1.3:1	297	5×10^{-4}	84768.5
7	114	95	1.6:1	577	6×10^{-4}	86686.1
8	119	100	1:1	864	2.1×10^{-3}	88828.1
9	127	107	1.1:1	987	3.6×10^{-3}	91424.1
10	135	124	1:2.1	987	3.6×10^{-3}	97047.3
11	164	131	4.1:1	1050	1.43	110523.3

CONCLUSIONS

The following conclusions are made from this study

The heat and electrical power generated from palm kernel shell and palm fruits fibre have been determined

Maximum heat, pressure and electrical power were obtained at a mixture and combustion of 164 kg of palm kernel shell and 131 kg of palm fruits fibre.

At optimum combustion of palm kernel shell and palm fruits fibre, the pressure obtained was 50 bars, current was 5A, induced voltage was 210V, electrical power was 1050W and the heat produced was 110523.3kJ.

Palm kernel shell and palm fruits fibre if properly harnessed are capable of replacing fossil fuels in palm fruits processing.

Power generation are no longer constraints to palm fruit processing.

REFERENCES

Hartley, C.W.S. 1988. The Oil Palm. Longman Scientific and Technical Publishers.

Lugngkiattikhum P., Tangsathitkulchai C and Tanngsathitkuchai, M. 2008: Non-Isothermal Theromo Gravimetric Analysis of Oil Palm Solid Waste Resources Technology, Vol. 99, 2008 pp 986-997.

NBS, 2006. National Bureau of Statistics. Core welfare indicator questionnaire survey, Nigeria.

Pansamut, V. Pongrt V.; Intraagngesi, C. 2003: The Oil Palm. Department of Alternative Energy Development and Efficiency. Ministry of Energy, Thailand.

Pickard, M. D. 2005: By-products Utilization. in Bailey's Industrial Oil products. 6th Edition, Volume 4 – Edible Oil and Fat Products. Products and Publications. Shahidi, F. (ed). Wiley Inter-science.

RMRDC, 2006. Raw Materials Research and Development Council. Multi- Disciplinary Committee Report of Techno-Economic Survey on Motor Vehicle and Miscellaneous Sector 5th Update. December, 2006. 103 pages.

RMRDC, 2009. Raw Materials Research and Development Council. Multi- Disciplinary Committee Report of the Techno-Economic Survey on Food, Beverages and Tobacco 6th Update. December, 2009.

Acknowledgements: The authors wish to extend appreciation to Chief Agu Ojukwu the Managing Director of Pioneer Farms Ltd, Amaokwe Item for granting us the use of his mill for this experiment. The cooperation giving to us by the members of staff of the factory are also appreciated.