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THE USE OF SAWDUST AS AN ALTERNATIVE SOURCE OF ENERGY FOR DOMESTIC COOKING AND AS A MEANS OF REDUCING DEFORESTATION

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ABSTRACT

This paper presents the reports on the utilization of sawdust stove as a way of ameliorating the effect of perennial fuel crisis in Nigeria on domestic cooking and a means of reducing deforestation and subsequent desertification. The performance of the sawdust stove, in terms of cooking duration and specific fuel consumption, was compared with a conventional kerosene stove. Results obtained show that it takes less time and fuel material to cook with the sawdust stove than the kerosene stove.

KEY WORDS: sawdust stove, alternative energy source, domestic cooking, deforestation.

INTRODUCTION

The emergence of perennial fuel crisis in Nigeria has drawn attention to the need for energy experts to further concentrate on producing viable alternatives and/or complements to kerosene and cooking gas for domestic cooking. Hitherto, the most common sources of energy utilised for domestic cooking in Nigeria have been wood, kerosene and gas (LPG). In some homes electricity is also used. Electricity, even though, pollution free, the supply is erratic and unreliable. Gas burns quite efficiently but it is now expensive and out of reach of the common man (Adegoke, 1999).

Solar energy another possible alternative renewable energy source is rather location – specific in terms of utilisation. The associated problems of energy storage for use during the period of little or no sunshine also require technological artifacts that are presently very scarce in the country (Olorunsola, 1999).

Therefore, there is need to search for alternative means of energy especially for domestic use. Even in the developed countries, which hitherto depended on imported petroleum products as their major source of energy, efforts are being made towards the development of alternative sources. The United States of America, for instance, has reviewed the technology for obtaining energy and synthetic fuels from biomass, which is already a commercial energy resource (Klass, 1983).

Wood has for long served as one of the energy sources known and used by mankind, for cooking in both urban and rural areas of developing countries. In Nigeria, fuel wood is still the most utilized energy for cooking (Danshehu *et al*., 1992). Though wood-fuel is a renewable source of energy, several decades of wood-fuel exploitation over natural rates of regeneration has made wood-fuel availability more difficult. Earl (1975) and Openshaw (1978), estimate of wood-fuel consumption suggest a rate of consumption far outstrip supply.

The forest contains good variety resources – timber, firewood, building materials, vegetables and wild life. The indiscriminate removal of these forest resources and other green cover for day-to-day consumption is referred to as deforestation. Deforestation without a deliberate step of a forestation (replacement of green covers, i.e., tree planting) has serious environmental consequences. Tropical deforestation is a global concern. In Nigeria, tropical forest cutting occurs at rates higher than 3 percent per year (Chandler, 1990).

Several studies have established the fact that wood-fuel constitutes the bulk of energy used by rural households in Nigeria. Momoh and Soaga (1999) reported the work of Ogbona, who estimated that wood-fuel provided 60% and 92.3% of energy for cooking in urban and rural households respectively in the Savannah areas of Nigeria. Akinbami *et al*. (2001), reveal in their study that wood-fuel use in Nigeria as of 1999 accounted for 65.9% of the overall energy use in Nigeria. Also, Onuorah (1999) report that over 80% of Nigeria households depend on wood fuel for domestic energy.

The above statistics show the fact that wood-fuel consumption is a major and increasing cause of reduced tree cover in both forest and Savannah sector with attendant unsustainable deforestation that lead to severe degradation of the environment, lowering of water quality and productivity in agriculture generally (World Bank, 1992).

This problem of desertification occasioned by uncontrolled deforestation is enormous enough to disqualify any recommendation suggesting wood-fuel as a sole energy source for domestic cooking. With limited proven reserves of fossil fuels such as coal and oil, top priority should be given to preservation of existing forest coupled with good afforestation programmes to maintain ecological balance and reduce pressure on already depleted forests.

Until recently, sawdust, a by-product of saw milling operations, abound in large heaps in many parts of the country are normally burnt off, resulting in atmospheric pollution. These wastes and other agricultural residues like rice husk, millet husk could be used as possible viable alternative energy sources for domestic cooking. Several technological approaches have already been developed for converting such materials into high-grade fuel products with enhanced handling and combustion characteristics (Olorunsola, 1996).

The utilisation of sawdust stove for domestic cooking will go a long way in not only ameliorating the impact of energy crisis, but will also reduces considerably both the cost of energy consumed by domestic cooking and deforestation. This paper presents the report on performance evaluation of sawdust burning stove for domestic cooking as means of reducing deforestation and to meet the domestic energy demands.

CHEMICAL COMPOSITION AND COMBUSTION OF SAWDUST

Sawdust is a fine waste product obtained from the process of wood sawing. Since it is mainly from wood, it possesses all the characteristics and properties of wood during the process of combustion. The composition of sawdust varies with tree species and wood materials. Sawdust is a composite of three polymers; cellulose [$C_6H_8O_4$], lignin [$C_6H_{10}O_3$ $(OCH_3)_{0.9-1.7}$] and hemicellulose such as Xylen ($C_5H_8O_4$). Sawdust of hard wood contains 43% cellulose, 35% hemicellulose and 22% lignin. While that of softwood are 43% cellulose, 28% hemicellulose and 29% lignin. The average element composition for all varieties of wood contains by sawdust are: 54% carbon, 40.5% oxygen, 3% Hydrogen, 1% Nitrogen, 0.5% sulphur and 1% Ashes (David, 1978).

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The combustion of sawdust requires a given amount of this fuel to react with sufficient oxygen in a ratio that will ensure complete combustion and maximum efficiency. The necessary oxygen required for combustion is supplied through the atmospheric air. The quantity of air that can give complete combustion of the fuel is the minimum required air, which is referred to as stoichiometric air. Therefore, to ensure maximum utilisation of fuel (complete combustion) and high combustion efficiency, excess air must be allowed into the system. This is the principle that guided the construction of the sawdust stove.

DESCRIPTION OF SAWDUST STOVE

The sawdust cooking stove as shown in Fig. 1, is making use of only sawdust as the fuel and the design eliminates completely the need of the support of firewood. The stove consists of the inner burner, outer burner, stove housing, the grill, base plate and stand. They are assembled together in a way that will allow proper flow of air.

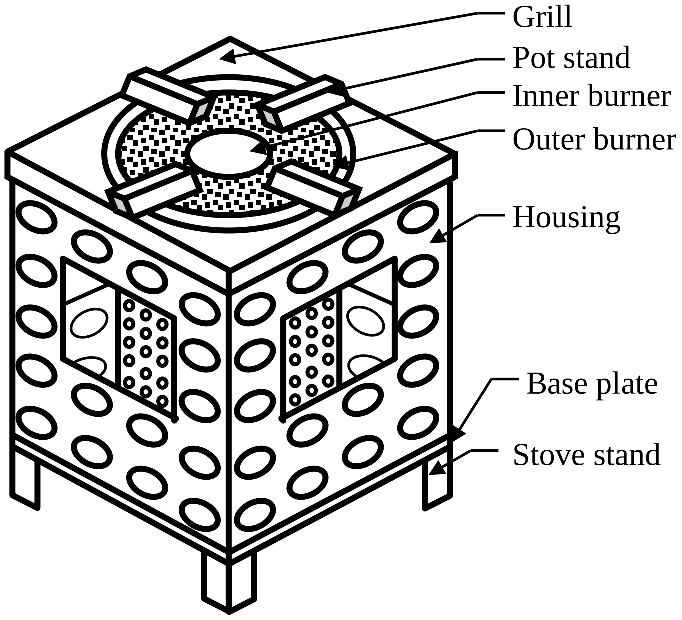

Fig. 1: Sawdust Cooking Stove.

Inner Burner is made of mild steel sheet of 1.0 mm thickness. This is the component that envelops the burning chamber, it also directs the flame upward, and it allows the entrance of enough air through its perforated holes into the system for complete combustion.

Outer Burner is also made of mild steel sheet of 1.0 mm thickness. The perforated holes on the burner regulate the flow of air through the stove's sides into combustion zone.

Stove Housing is the main body of the stove. It housed other components and gives shape to the stove. It is made from a mild steel sheet of 1.5 mm thickness.

Base Plate is the component that carries the whole weight of the stove. The combustion assembly is set on it and it is made from a mild steel plate of 2.5 mm thickness. The base plate is constructed with the stand, which supports the stove. The stand is used to raise the stove above the ground level for free entrance of air into the combustion area via the hole in the base plate.

The grill is the top cover of the stove, and is constructed with the pot stands that carry the pot. The arrangement is in such a way that the pot-stands give sufficient gap between the stove and the pot for easy flow of flue gases and at the same time; the heat transfer to the pot is not affected.

PERFORMANCE EVALUATION

The sawdust cooking stove and kerosene stove were set in the laboratory where a number of tests have been carried out on them.

Burning Rate of Sawdust.

Tests on burning rate were carried out with sawdust of five different types of common wood (alfara, mahogany, masonia, cida and iroko). For each test the sawdust stove was loaded with the sawdust of a particular wood, the weight of the sawdust and time taken to burn completely inside the stove were recorded. This test was carried out for each of the five types of wood. The results are shown in Table 1. From this table, the average rate of burning of sawdust in the stove is 0.00252 kg/min.

Table 1: Burning Rate of Sawdust of Various Species of Wood.

S/N	Type of Sawdust	Weight (Kg)	Time Taken to Burn (min).	Burning Rate (kg/min)
1	Alfara	0.151	50.33	0.0030
2	Mahogany	0.152	54.29	0.0030
3	Masonia	0.154	64.17	0.0024
4	Cida	0.152	66.09	0.0023
5	Iroko	0.156	74.29	0.0021

Water Boiling Tests

According to Danshehu *et al*. (1992), Water Boiling Tests (WBTs) are short, simple simulations of standard cooking procedures. They measure the fuel consumed and time required for simulated cooking. WBTs are usually employed to investigate the performance of stove under different operating conditions to an expected stove performance. It is used by stove designers, researchers and field workers for quick comparison of the performance of stoves. In water boiling test, stove efficiency is expressed by percentage heat utilized (PHU).

$$\mathrm{PHU} = \frac{\text{Net Heat Utilized}}{\text{Net Heat Supplied}} \times 100\% \qquad (1)$$

Controlled Cooking Test

The Controlled Cooking Test (CCT) is to compare the fuel consumed and the time spent in cooking of meal on different stoves. The tests were carried out with two food items (rice and beans). The controlled cooking tests enable the determination of the specific fuel consumption, which expresses the amount of dry sawdust required to obtain 1 kg of cooked food. For each of the test that were carried out, the cooking pots were first weighed, after which 0.4 kg of food was placed in each of the pots which already contain 1.5 litres of water. The weights of the fuel in each of the stoves before and after the tests were noted. The data collected were used in calculating the specific fuel consumption (SFC) using the following equations:

$$\mathrm{SFC} = \frac{\text{Mass of consumed fuel}}{\text{Total mass of cooked food}} \qquad (2)$$

$$SFC = \frac{W(1-Y)-1.5X}{M_{pf} - M_p} \quad (3)$$

Where W = Mass of fuel (kg)
Y = Moisture content of fuel (%)
X = Mass of fuel remaining after the test (kg)
M_{pf} = Mass of the pot with cooked food (kg)
M_p = Mass of the pot (kg)

The specific fuel consumption for the sawdust stove and kerosene stove are given in Table 3.

Time Spent in Cooking

The time spent in cooking per kg of cooked food is calculated using Eqn. 4 and the results are also given in Table 3.

$$Time\ spent = \frac{Total\ time\ spent\ in\ cooking}{Total\ mass\ of\ cooked\ food} = \frac{T_c}{M_f} \quad (4)$$

Where T_c = Total time spent in cooking
M_f = Mass of cooked food

RESULT AND DISCUSSION

The rate of burning of sawdust as shown in Table 1 depends on the type of parent wood from which the sawdust was generated. The results show that sawdust of hardwood like Iroko and cida has low burning rate of 0.0021 kg/min and 0.0023 kg/min in the sawdust burning stove respectively than that of soft wood like alfara with burning rate of 0.0030 kg/min. Since the sawdust from sawmill industries are mostly mixture of these species of wood, the average burning rate using the stove is found to be 0.00252 kg/min.

This burning rate is lower than 0.0035 kg/min obtained by Kaoma and Kasali [10] from the test of coal briquettes in a Zambian clay stove. Since the burning rate determines the life span of the fuel during combustion, that is, the higher the burning rate the shorter the life span of the fuel. Therefore, it is often disadvantageous to have too high a burning rate. Hence the lower burning rate obtained from the combustion of sawdust in the stove shows that the sawdust stove could handle the fuel materials more economically.

From the comparative studies conducted, the results shown in Tables 2 and 3 reveal that the sawdust stove has potentials greater than that obtained with kerosene stove. The heat utilized in the sawdust stove was found to be 34.6% of the heat supplied, while that of kerosene stove was 32.1% for similar water boiling test.

Table 2: Percentage Heat Utilized (PHU)

Quantity of Water Used	Percentage heat utilized (PHU)	
	Sawdust Stove	Kerosene Stove
5 litres	34.6%	32.1%

Table 3: Control Cooking Test Results.

Type of Stove	Specific fuel Consumption (kg/kg of Cooked food)		Time Spent in Cooking (min/kg of cooked food)		Time Spent in cooking 0.4 kg food (min)	
	Rice	Beans	Rice	Beans	Rice	Beans
Sawdust Stove	0.20	0.27	78.75	106.88	31.50	42.75
Kerosene Stove	0.21	0.29	88.13	120.63	35.25	48.25

The time taken to cook 0.4 kg of rice and beans on sawdust stove were 31.50 minutes and 42.75 minutes respectively while the time taken to cook the same quantity on kerosene stove were 35.25 minutes and 48.25 minutes respectively. These results show that the sawdust stove cooks food faster than kerosene stove. Although there is no much difference in specific fuel consumption of the two stoves as shown in Table 3, nevertheless, the superiority of sawdust stove is demonstrated, as specific fuel consumption of sawdust for cooking rice and beans were 0.20 and 0.27 kg/kg of cooked food respectively, while that of kerosene stove were 0.21 and 0.29 kg/kg of cooked food respectively.

Problems Associated with the use of the Sawdust Stove

Ignition or starting problem: Unlike kerosene stove that required just a spark of fire on its wicks before it will start and continue to burn, the sawdust stove required a more intense heat to ignite the sawdust. Therefore, to start up the fire in the sawdust stove, the fuel (sawdust) needs to be pre-heated with other easily inflammable materials such as papers.

Control Problem: Another area that needs improvement on the stove is the area of control. The design of the stove can be improved by incorporating a regulator at the base of the burners to adjust the fuel level between the inner and outer burners. This adjustment will help in increasing and decreasing of the heat intensity in relation to the top surface of the cooker.

Smoking Problem: During the testing, an appreciable smoke production was observed in the burning of sawdust. According to Adegoke [1], this smoke production can be drastically reduced by mixing sawdust with other biomass materials such as palm kernel shell, charcoal shell and coconut fibres to form sawdust briquettes, which will also improve the calorific values and facilitate storage and easy transportation of the fuel.

CONCLUSION

Wood-fuel which hitherto constitutes the bulk of energy used for cooking by rural households in Nigeria has contributes majorly to deforestation and severe degradation of the environment. Sawdust, a by-product of saw-milling operations could be used as possible viable alternative energy source for domestic cooking.

In the evaluation of the performance of sawdust stove, the average rate of burning of sawdust was found to be 0.00252 kg/min. The stove showed better performance when compared with conventional kerosene stove. The efficiency as expressed by percentage heat utilized (PHU) was 34.6% for the sawdust stove while that of kerosene stove was 32.1%.

It is concluded that sawdust is not only cheaper and readily available than kerosene; it takes less time and fuel materials to cook with sawdust stove than the kerosene stove. The mass-production of the stove will enhances the utilization of wastes from saw-mill industries, the preservation of existing forest, and reduction in the pressure on already depleted forests.

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