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Firewood-Stove Made in Rwandan Rock

Munyaneza Jean de Dieu[1]

[1] TUMBA COLLEGE OF TECHNOLOGY

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Abstract

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Index terms— stove made in volcanic rock, water boiling test, firewood.

1 Introduction

ooking stoves are most common devices for cooking and heating food by burning wood or fossil fuels. In regions where biomass is a traditional fuel for cooking, improved cook stoves can enhance indoor air quality, personal health, livelihoods, and the environment while substantially reducing greenhouse gas (GHG) emissions. Although ongoing efforts have successfully disseminated improved stoves that achieve many of these benefits, substantially greater emissions reductions are needed to comply with international guidelines for indoor air quality and to limit GHG emissions like black carbon [1]. Wood fuel contributes 86% to the primary energy balance and about 97% of Rwandan households are dependent on wood for cooking ??NISR, 2008b). Regionally in East African Community (EAC) countries and DRC, the figures on wood fuel reliance are similar: Uganda 98%, Tanzania 96%, Kenya 90%, and the Democratic Republic of Congo (DRC) 95% (UNDP, 2009b) [1]. Due to above issues especially in Rwanda I have manufactured a precious stove made in volcanic rock for reducing firewood use, increasing efficiency, lowering emissions, and improving health.

2 II.

3 Literature Review

Around half of the world's population burns solid biomass fuels for cooking and heating needs. Throughout poor, rural areas of sub-Saharan Africa, biomass is the dominant fuel, and cooking is usually performed using a simple three-stone fire or "open fire". Particularly in high-altitude areas, where nighttime temperatures are colder, cooking is often performed in poorly ventilated structures [2]. Incomplete combustion of these fuels and poor ventilation result in high indoor concentrations of health-damaging pollutants including particulate matter and carbon monoxide ??Jetter and Kariher, 2009; ??ehfuess, 2006). In addition, especially in regions where biomass is scarce, time and effort spent gathering firewood can be a substantial burden on households, particularly children and women ??Rehfuess et al., 2006).

4 a) Cooking test results of some stoves used in sub-

Saharan Africa and America i. Ugastove, StoveTec and Three-stone stove

The Ugastove stove showed fuelwood savings of 46%, and the StoveTec showed fuelwood savings of 38%. In a region where fuel scarcity is a serious problem, fuelwood savings of 38 to 46% can have a large impact. The second key technical metric measured was cooking time. The three-stone fire required approximately 17 min to cook matooke. The Ugastove showed a statistically significant increase in cooking time of 27% over the 3-stone fire (22 min), whereas the StoveTec stove showed only a slight increase (18 min, or an additional 5%) which was not statistically significant [2].

Another study by Aprovecho found that the StoveTec stove reduced the global warming impact by 40-60% compared to the three-stone fire ??MacCarty et al., 2008a). A comprehensive review of 50 different cookstove models by MacCarty et al. (2010) tested several different Rocket-type stoves, including the StoveTec model with and without various accessories, and found that, on average, the fuel use was reduced 33%, CO emissions by

75%, and PM emissions by 46% in comparison to the three-stone fire. These findings on fuelwood savings can be combined with data on frequency of cooking various foods in village households to create a rough estimate of yearly fuelwood savings [2].

In the Uganda study area, households cooked plantains more than any other food, on average, 11 times per week. Across all 60 household tests, the average quantity of food cooked was 3.19 kg, and the average amounts of fuelwood used were 1.77 kg for the three stones fire, 0.92 for the Ugastove and 1.04 for the StoveTec. Thus, the average total fuelwood savings for use of the Ugastove in place of the three-stone fire was 0.85 kg/meal, which, multiplied by 11 meals per week and 52 weeks per year, comes to around 490 kg of fuelwood saved per year. The main user complaint with the Ugastove (over 80%) was the large increase in cooking time, a difference which was confirmed with technical measurements. Other unfavorable traits included the tendency of the metal shell of the Ugastove to become hot to the touch, making cooking difficult, as well as the Ugastove's bulky, tall, and top heavy design [2].

5 b) Nepalese, Darfour and Rocket stove

These three types of Stoves are the first used in Rwanda from 2006 in order to reduce deforestation rate and environmental degradation. c) Some stoves used in South America and Central America A comparison was made of the thermal efficiency and emissions of the traditional three-stone fire and the "Plancha" improved stove-burning wood. Simultaneous measurements of efficiency and emissions of suspended particles and carbon monoxide were taken in order to incorporate both of these factors into a single standard of performance -emissions per standard task. These factors were measured during both a Water Boiling Test (WBT) and a Standardized Cooking Test (SCT). No statistical difference in efficiency between the Plancha and traditional stove was found.

The Plancha required more time to perform both of the tests, and this difference was statistically significant (p=0.048) for the WBT. The Plancha emitted 87% less suspended particles less than 2.5 jim in diameter (PM2.5) and 91% less CO per kJ of useful heat delivered compared to the open fire during the WBT [3].The relative environmental performance of the Plancha improved during the SCT, resulting in a 99% reduction of total suspended particulate matter (TSP) emissions and a 96% reduction of CO emissions per standardized cooking task.

6 III.

7 Methods a) Case Study

Rwanda is a country located in Southern sub Saharan region in Africa, in exactly East Africa region with a population of approximately 11.4 million (2011) on total size of 26,338 square kilometers. Rwanda is located at 2 degrees south and 30 degrees east. At 433 inhabitants per square kilometer, Rwanda's population density is amongst the highest in Africa. In Rwanda, wood fuels represent 77% of all wood needs (GTZ, 2008). Almost 97% of all rural households use wood fuels as their cooking fuel, fuel wood accounts for 91% and charcoal for 6% (MININFRA, 2009a). The increasing overall demand for wood has put additional pressure on forest resources and reduced the capacity of forests to supply wood products sustainably. There is a permanent demand/supply imbalance [4]. Lack of access to modern fuels coupled with widespread poverty makes wood fuel the most accessible and often the only cooking fuel available to the majority of Rwandan households (Table **??** as well as cottage and agro-industries. ? Deforestation rate at 252.6 ha of the total areas of the forest of SHINGIRO SECTOR, 4% of it are cut yearly.

8 b) The Objectives of the Project

The main objectives of this project are:

? Design and fabricate the improved cooking stove made in volcanic rock. These rocks that fill all requirements to be raw materials for ICS are located in Shingiro sector only.

? Supply the improved cooking stove made in volcanic rock to rural people which has thermal efficiency of more than15% and smokeless,

? Train cooperatives or individual people on how we fabricate the stoves made in volcanic rock through Muneza Biomass Engineering Company.

9 c) Methodology

In order to carry out the project, we referred on the collected data based on the questionnaires asked to the SHINGIRO Sector's Population; the site survey (engineering survey) results conducted in order to characterize the site and the theories of Stoves. During the site visits, most of the questions asked are related to know the types of stove used per family, location of Energy sources used by Shingiro's population, availability of firewood nearest the people of Shingiro sector and the identification of actual application of volcanic rock. Due to huge pressure on cutting forest in different areas of Rwanda as you see on the below table.

10 Table 3 : Wood Consumption Projections (baseline, t/yr)

The survey shows that different stones or rocks locate in Shingiro Sector can increase the number of improved cooking stoves which are precious stove because have the ability to conserve heat from burnt firewood until one hour after removing all firewood only small charcoal formed during cooking process stay in the combustion chamber.

Pictures 1a: volcanic rock, 1b: Stove made in volcanic rock, 1c: Painted stove made in volcanic rock

11 d) Design and fabrication stove made in volcanic stove "RONDEREZAURUTARE"

The design principles on this new improved cooking stove made in volcanic rock were respect all international standards refer to actual stoves such as Canarumwe stove, Darfour stove and Nepalese stove, etc that are currently used in Rwanda. Only one differs from them is the material of construction.

For constructing the improved cooking stove made in volcanic rock, we follow these steps:

i. Select a good fragile volcanic rock which has 50 cm diameter and 40cm height dimensions (this fragile volcanic rock can be found underground in one meter of depth or aboveground). ii. See if that selected volcanic rock has no cracks. iii. Measure the external dimensions of ICS on volcanic rock so as to get cylindrical form.

iv. Form the volcanic rock to give it cylindrical form by using a machete and small ax. v. Measure the dimensions of the top hole and height of combustion chamber by using a measuring tape and scriber on the cylindrical form. vi. After getting a cylindrical form, start to dig a volcanic rock in order to get a combustion chamber by using a drill bit and hammer according to the given dimensions. vii. Measure the dimensions of the feed hole (entrance) on the cylindrical form according the given dimensions. viii. Dig the entrance by using drill bit and hammer.

ix. Harmonizing the combustion chamber and entrance using the drill bit smooth fully. x. Make on its top three support pot. xi. Paint it and let the ICS for one day on the sun to be dried.

12 e) Drawing of medium type of firewood-volcanic stove (RONDEREZA URUTARE)

IV.

13 Findings and Analysis

As the water boiling test is used to quantify thermal efficiency and firepower for any type of stove, we have made a WBT for stove made in volcanic rock (called RONDEREZA URUTARE in Kinyarwanda language) three times and we found the following results.

14 Conclusion

During our research project we faced different problems of cooking energy in Rwanda (especially in rural areas) such as health problem, environment problem and scarcity of fuel wood (fuel for cooking) caused by the use of traditional (three stone stove) stove in cooking activities and a rapid increased number of Rwandan population, various researches have been carried out to make the stove which can save the fuels and bring good health condition processes. The main objective of this project was to construct an efficient and smokeless stove made in volcanic rock which can replace the open air stove for the following reasons:

People using three stones suffer from respiratory disease, eye ailment caused by smoke and risk of scads due to open fire. There is high pressure of cutting trees in different areas of Rwanda which contribute to global warning as the number of Rwandan populations increased. There is a lot of volcanic rock for making this type of stove in volcanic region (Musanze District) which is a simple and cheap technology and does not require special skills as well as a big investment in terms of money and machine.

So the project of construction of improved cooking stove made in volcanic rock come out with the following solutions: The ICS made in volcanic rock consumes less firewood and the efficiency is higher than other types of stove (Nepalese type its thermal efficiency is 16.81%, Darfour type its thermal efficiency is 12.72% and rocket type its thermal efficiency is 16.21%). It avoids the diseases from smoke and offer good health to their users. The cost of this new stove varied between 2.15$ to 4.3 $ in different part of Rwanda and from 2006 up to 2014; around forty thousand (40,000) of volcanic stoves were supplied in different part of Rwanda and many people benefit their advantages over existing stoves. [1] [2] [3]

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Figure 1: Table 2 :

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Type of stove	Thermal efficiency, %		
	Cold	Hot	Average
Nepalese type	14.98	18.64	16.81
Darfour type	11.88	13.56	12.72
Rocket type	11.38	21.04	16.21

Figure 2: ooPictures 2 :

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[Note: (Source: Activity report of Biomass expert Mr. Satish Aryal 2009, Rwanda)]

Figure 3: Table 1 :

4

S/N		Thermal efficiency %		
	Cold	Hot	Simmer	Average
Day1	24%	25%	54%	34.33%
Day2	25%	25.6%	53%	34.53
Day3	25.2%	26%	55%	35.4
Average 24.73% 25.53%			54%	34.75%

A well designed volcanic stove (

Figure 4: Table 4 :

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