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AN EXPERIMENTAL STUDY ON "ROCKET WATER HEATER"

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Abstract: In developing countries, India in particular, biomass is the main resource for all domestic needs where people of rural sectors totally depend on it. They cook food and heat water in the winter season for the purpose of bathing on a traditional biomass three - stone fire cook stove. The present study evaluates the performance of "Rocket Water Heater" which has been introduced recently in the local market. For present experimental work, this biomass appliance of 9 liters water capacity was fabricated in workshop of Mechanical Engineering department, Sobhasaria Engineering College, Sikar. The Water Boiling Test (WBT) which is a simplified simulation of cooking process has been used to measure the thermal efficiency of "Rocket Water Heater". The results indicate that the thermal efficiency in the range of 18 to 29.5 % is for "Rocket Water Heater" under various operating conditions.
Key words: Rocket Water Heater, Thermal efficiency, Water Boiling Test.

I. INTRODUCTION

In the early years three stone fires were used for roasting the meat and to protect from wild animals [1]. The history of cook stove had started with the invention of fire and from archaeological excavations at Chou Kutienin China. In rural areas, people use wood and other biomass fuel for cooking, heating room, heating water for bathing and boiling water for drinking [2]. Along with the progress of human civilization, the condition of open fire improved and cook stove came in existence. The Rocket Stove is a clean burning and fuel-efficient cooking stove which can use thin sticks as fuel [3]. Rocket stoves make cooking with fire easier, safer and faster than with open fires. They are quicker to start; little tending and can meet the specific needs of domestic and small/large scale commercial cooks. Due to excellent fuel efficiency, Rocket Stoves reduce the time to start a stove and to cook/boil the food. A user does not have to blow air into the stove to fan the flame. Once lit, the stove fire will burn continuously unless one stops putting firewood into the stove. Increased amount of air helps the fire burn hotter and helps to improve the burring of the firewood.

II. DESCRIPTION OF APPLIANCE

The detailed description of "Rocket Water Heater" is as follows:

- Specifications of combustion chamber
  - Diameter = 15.5 cm.
  - Height = 22 cm.
  - Wire mesh at the bottom
- Specifications of water tank
  - Capacity = 9 Litres
  - Inner Diameter = 15.5 cm.
  - Outer Diameter = 100 cm.
  - Height = 20 cm.
- Specifications of chimney
  - Diameter = 6.5 cm.
  - Height = 19 cm.
- Diameter of inlet at top for pouring water =3.5 cm.
- Diameter of outlet at bottom for exit water =3.5 cm.
- Material used for Rocket Water Heater= Sheet Metal (22 gauge)
- Height of stand = 34 cm.

Fig. 1 Photograph of "Rocket Water Heater"

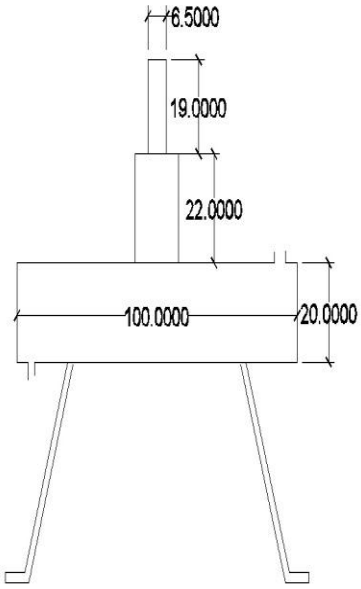

Fig 2 Specifications of Rocket Water Heater

III. TEST PROCEDURE

There is no standard protocol for testing such an appliance, as for biomass cookstoves, is available in literature. But, since the appliance is used for heating water for bathing purpose, to test its efficiency, Water Boiling Test, which is recommended for testing Improved Biomass Cookstove, is used as the standard procedure for Rocket Water Heater also. To be specific, Cold Start High Power Test of Water Boiling Test (WBT) protocol 4.2.2 is used [4]. Experiments were conducted in the thermal laboratory of Sobhasaria Engineering College, Sikar. For the Cold-Start high-power phase, the tester begins with the Rocket Water Heater at room temperature and uses fuel from a pre-weighed bundle of fuel to boil a measured quantity of water in a standard pot. This is a simplified simulation of the cooking process. It is intended to measure how efficiently a stove uses fuel to heat water in a cooking pot under various experimental conditions.

A. Cold start test for Rocket Water Heater

- Measure 9 litres of water in the measuring beaker.
- Fill the measured water in the Rocket Water Heater.
- Insert the thermocouple lead in the water chamber.
- Note down the initial temperature of water.
- Fill the combustion chamber with one bundle of fuel (batch size 50 grams)
- Set the timer to start the experiment.
- Ignite the fire in the combustion chamber with the help of kindling of diesel.
- Once fire is well set start the timer in the stop watch.
- Pour the next set of fuel batch (50 grams) after two minutes and note down the temperature.
- Repeat this procedure until the temperature reaches its maximum value i.e. 98°C or 99°C.
- Now extinguish the fire.
- Conduct various experiments for varying fuel batch sizes (25grams and 50 grams) and varying water quantities (5 litres, 7 litres and 9 litres).

Fig. 3 Experimental set up for "Rocket Water Heater"

IV. EXPERIMENTAL OBSERVATIONS AND ANALYSIS

Experiments were conducted on Rocket Water Heater for different fuel batch sizes (25 grams and 50 grams) and for different quantities of water (5 litres, 7 litres and 9 litres). The wood used as fuel is Meranti wood having net calorific value of 12259 kJ/kg. Results of experiments conducted having fuel batch size 25 grams for different water quantities (5 litres, 7 litres and 9 litres) are shown with the help of graph plotted below:

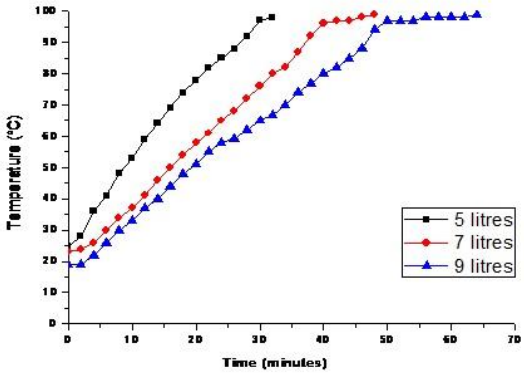

Fig. 4 Graph Temperature v/s Time for Rocket Water Heater (Batch size 25 grams and water quantity 5, 7, and 9 litres)

Results obtained from experiments conducted having batch size 50 grams with varying water quantities (5 litres, 7 litres and 9 litres) are shown with the help of graph plotted below:

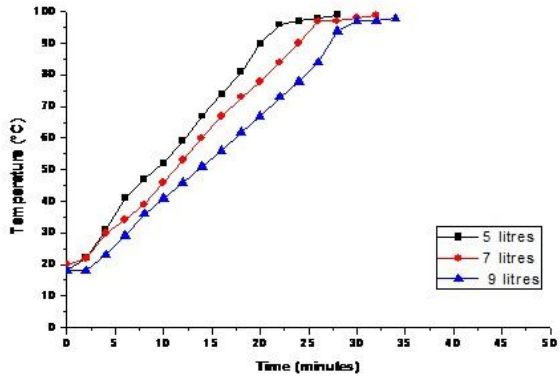

Fig. 5 Graph Temperature v/s Time for Rocket Water Heater (Batch size 50 grams and water quantity 5, 7, and 9 litres)

Thermal efficiency of "Rocket Water Heater" for the experiments is estimated using the formula described below and tabulated in Table 4.1.

Thermal efficiency is estimated as following:

$$\eta = \frac{Useful\ \ Heat}{Heat\ \ Input}$$

$$\eta = \frac{M_w C_p (T_2 - T_1)}{M_f CV} \qquad (6.1)$$

Where,

Mw = Mass of water to heated in kg (Assuming 1 litre = 1 kg).

Mf = Mass of fuel burnt in kg.

Cp = Specific heat of water taken as 4.186$\frac{kJ}{kg.K}$
CV = Net Calorific Value of wood used as a fuel is taken as 12259 kJ/kg.
T2 = Final temperature of water.
T1 = Initial temperature of water at the time of start.

Table 1: Thermal Efficiency for different fuel batch sizes and varying water quantity

S. No.	Water quantity	Thermal Efficiency (%) for fuel batch size of 25 grams	Thermal Efficiency (%) for fuel batch size of 50 grams
1.	5 liters	29.02	18.21
2.	7 liters	29.06	22.21
3.	9 liters	29.8	27.65

V. CONCLUSION

The "Rocket Water Heater" has been introduced in the area recently for heating water. The thermal efficiency of "Rocket Water Heater" is found in the range 18 to 29.5 % for quantity of water varying between 5 to 9 liters and fuel batch size of 25 grams and 50 grams loaded after every two minutes. For 25 grams batch size, thermal efficiency is constant at around 29%, whereas for 50 grams, it is varying between 18 to 28%. Also "Rocket Water Heater" gives more thermal efficiency for batch size of 25 gram as compared to 50 gram batch size. It appears that a small batch size of 25 gram is more appropriate for the 9 litres capacity of "Rocket Water Heater". Further Rocket Water Heater" is being tested for half tank, three fourth tank and full tank water filled. It has been found that it gives maximum efficiency for its full capacity or when it is completely filled with water for heating purpose.

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