Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7273

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **7 (1):** 108-112 (2019)

Short Communication

Fabrication and Testing of Energy Efficient Chulha-Its Comparision with Traditional Chulha Used in Near by Village

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Received: 30.12.2018 | Revised: 5.02.2019 | Accepted: 12.02.2019

ABSTRACT

The study was carried out in 2016 at several villages of Mungeli district. In this study, an improved two pot cook stove was designed, fabricated and tested to evaluate its performance. In this work we have fabricated a chulha (cooking stove) that is more energy efficient as compared to the chulha type used in the nearby villages. Both the chulhas were fabricated with the black soil. The black soil was mixed with the cow dung. Improved cook stove was fabricated with the aid of mould. The mould was fabricated by welding and forging the iron plate and then finally the finished touch to the chulha was given by the cow dung. The chimney was installed in the rim of the iron plate. To evaluate the performance of the traditional stove and improved cook stove, and to compare them, test on burning rate of the fuel, water boiling test, power output rate was conducted. The thermal performance of the improved two pot stove was compared with that of traditional mud stove. The results obtained showed a better performance of the improved two pot cook stove than that of the traditional mud stove. The burning rate of the traditional mud stove had a higher burning rate then the improved two pot cook stove. Also the traditional mud stove has less power output rate then the improved two pot stove. These results shows that biomass as fuel using rural population need a more efficient stove for cooking to replace the traditional stoves.

Key words: *Traditional cook stove, Biomass, Two pot cook stove, Chulha, Thermal efficiency.*

INTRODUCTION

In the developing countries including India most of the population lives in rural area and depend on biomass especially wood, cow dung, charcoal, etc. for cooking purpose. People around the world use wood and biomass as their primary fuel source. However, burning wood raises many issues about which to be concerned. Traditional wood burning stoves are terribly inefficient, unsustainable, and polluting. Thus, stove technology could be significantly improved upon to reduce these negative effects by increasing efficiency through advanced combustion techniques.

Cite this article: Kosariya, Y. K., Bhaskar, P., Rashmi, Suyashlata and Chandrakant, Fabrication and Testing of Energy Efficient Chulha-Its Comparision with Traditional Chulha Used in near by Village, *Int. J. Pure App. Biosci.* **7(1):** 108-112 (2019). doi: http://dx.doi.org/10.18782/2320-7051.7273

First evolution in cook stove took place when open fire cooking was replaced with three stone fire arrangement in which three stones were arranged approximately 120 degrees from one another. Three stone fire arrangement had many drawbacks like dispersion of flames and heat during windy condition. Exposure to heat, as well as fire hazard besides the problem of low efficiency three stone fire arrangement, as a result the arrangement for better cook stove arose which give rise to U-shaped mud cook stove/traditional cook stove. The traditional cook stove solved many of the technical problems such as, enhancement of thermal efficiency by many folds. However, the health, socio economic and cultural problems were not solved completely. With respect to stove technology, the issues of efficiency and sustainability are inextricably linked. Forests in developing countries are rapidly decreasing and the ratio of forests-to-people is less than half of what it was in 1960. In 1989 study of 15 developing countries demonstrated a staggering demand for fuel wood. Furthermore, due to resource availability and the economic situation of the people who use wood burning stoves, the world's poorer half, alternatives to wood and biomass energy are not currently viable or affordable. In fact, many families spend more money on fuel wood than on food, drastically the nutrition levels of the family (Whitfield). Thus, by maximizing the efficiency of wood burning stoves both environmental, economic, and health gains could be achieved. Wood burning stoves also create a great deal of pollution. The fine particulates and carbon monoxide released by wood from incomplete combustion cause acute respiratory ailments, ear and eye problems, breathlessness, chest pains, headaches, dizziness, and more - much of which affects women and children. To minimizing harmful effects with less use of resources this study was carried out at nearby villages.

MATERIALS AND METHODS

An improved two pot cook stove model was designed, fabricated and tested for the experimental study beside the traditional cook stove. Structural steel was used as material of construction for the grate in the improved biomass cook stove and for the insulation purpose mixture of mud and cow dung was used. Beside this, the traditional cook stove was modified using same material as for traditional. The stove was constructed with locally sourced materials mud and rice husk to keep the cost as low as possible to enhance affordability by low-income households. Different types of wood for testing cook stoves and the materials for the construction of cook stove were available. Two different models of cook-stove were designed and fabricated in the workshop for the experimental study. In these models combustion is taking place simultaneously. The water boiling test for finding the thermal efficiency of cook stove was carried out. The room temperature shall be 25±5 ºC at the beginning. The air of the test room should be free from draughts which is likely to affect the performance of the chulha. The housing was fabricated from well insulated earthen mixture of clay and crop residue in 3:2 ratio of 7 cm in thickness and having two chambers, the upper one is combustion chamber and lower is ash collection/ flue chamber. The combustion units and the chimney pipe are mounted on the chamber. The height of the chimney can be adjusted according to the height of the room. Bricks are used as regulators to control the volume of air admitted through the openings into the fire-box.

Observations recorded

Burning rate

The procedure and formula employed in the calculations of burning rate of fuel wood was based on the approach by Bolaji and Olalusi[2].

$$R = \frac{100(\mathrm{Wi} - \mathrm{Wf})}{100 - \mathrm{M(t)}}$$

Where,

R =Burning Rate, kg/hr.

W_i =Initial weight of fuel at start of test, kg;

W_f =Final weight of fuel at end of test, kg;

M = Moisture content of fuel, %;

t = Total time taking for burning fuel, hr.

Thermal efficiency

The procedure and formulae employed in the calculations of thermal efficiency was based on the approach used as per chulha - specification in (IS 13152, 1991).

$$Thermal\ efficiency, \% = \frac{HU}{HP} \times 100$$

Where,

HU = Heat utilized

HP = Heat produced,

Power output rate

The power output rating of a chulha is a measure of total useful energy produced during one hour burning of fuel wood. It was calculated as per chulha - specification (IS 13152, 1991).

$$P = \frac{F \times CV \times Te}{860 \times 100}$$

Where,

F = Quality of fuel wood burnt, kg/h;

CV= Calorific value of fuel wood, kcal/kg;

T_e = Thermal efficiency of the chulha

Water boiling tests

It is the measure of fuel consumed and time required for simulated cooking. Water boiling tests are usually employed to investigate the performance of stove under different operating conditions to an expected stove performance.[4].

Instruments and Accessories-

Bomb calorimeter - Find calorific value of fuel kilo joule per kg
Mercury in glass thermometers (0-100ºC)
Single pan balance 1 kg capacity (dial with least count of 10 g)
Measuring jars; 1, 2 and 5 litre capacity
Stop-watch or time measuring device
Pairs of tong, metallic tray and sticks, etc. Piece of clean cloth

Figure1. Fabrication of two pot advance chulha

Table1. Specification of fabricated two pot chulha

Parameter	Dimension
Length of stove	70 cm
Width of stove	40 cm
Height of stove (front)	30 cm
Height of stove (back side)	30 cm
Fuel entrance gate height	18 cm
Fuel entrance gate length	15 cm
First pot hole diameter	22 cm
Second pot hole diameter	20 cm
Chimney diameter	9 cm
Chimney Length	120 cm (height of test room)

RESULT AND DISCUSSION

The water boiling test was conducted in steel container containing 1 litre of water and the temperature of the water was recorded at an interval of every 4 min. The results obtained showed that 1 litre water takes 12 min to boil in an improved stove while 16 min in traditional stove to reach the maximum temperature burning with a fuel wood of 1 kg and 1.25 kg of fuel wood for improved two pot chulha and traditional chulha. Also the burning rate obtained for the both stoves were 1.24 kg/h and 1.79 kg/h for improved two pot cook stove and traditional mud stove respectively (Table 2). This result shows that the traditional mud stove had a higher burning rate than improved two pot cook stove. The higher the burning rate the shorter the life span of the fuel, therefore, burning rate determines the life span of the fuel during combustion. It is often disadvantageous to have too high a burning rate. Hence the lower burning rates obtained from the improved two pot cook stove show that the two stoves handled fuel economically. These results show that biomass as fuel using rural population need a more efficient stove for cooking to replace the traditional stoves. The thermal efficiencies obtained from the improved two pot cook stove and traditional mud stove were 6.24% and 3.25%, respectively. The higher thermal efficiency of improved two pot cook stove was due to the minimal loss of convective heat current in the traditional stoves. Also, the higher burning rate of fuel in traditional mud stove lower the thermal efficiency of the stove since both parameters are inversely proportional to each other. The result showed better performance of improved two pot cook stove than traditional mud stove. The mean power output rate obtained for the traditional mud stove and improved two pot cook stove shows that the traditional mud stove had a less power output rate than improved three pot improved cook stove. The average power output rate of improved two pot cook stove was 0.42 kW and power output rate of traditional mud stove was observed 0.31kW. An energy efficient improved two pot stove was designed and fabricated to meet the cooking energy requirement of a family having 4-6 persons

Table2. Comparative parameters related to both chulhas

Particular	Advance two-pot cook stove	Traditional mud
Burning Rate, kg/h	1.24	1.79
Time taken to boil 1 lit. water, min	12	16
Power output rate, kW	0.42	0.31
Thermal Efficiency, %	6.24	3.25

CONCLUSION

The stove was constructed with locally sourced materials mud and rice husk to keep the cost as low as possible to enhance affordability by low-income households. It is concluded that there is a need to replace the traditional and inefficient cooking device with efficient cooking device such as the improved and advanced biomass cook stove. The water boiling test conducted showed that the same quantity of water takes more time to reach to its maximum temperature in traditional mud stove than the improved stove. The burning rate of the improved stove is lower as compared to the traditional stove. Thus shorter the life span of the fuel during combustion. The thermal efficiency of the improved two pot stove is more and satisfactory then the traditional stove. The traditional stove has poor power output rate than compared to the improved stove. Emission of smoke is reduced in the improved stove due to installation of chimney thus low health hazards.

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