Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 11	No. 4	pp. 621-624	2012

Original Research Paper

Performance Evaluation of Improved Cook Stoves

Ch. Someswararao, G. Prasanna Kumar*, Ch. V. V. Satyanarayana**
Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur, India
*Post Harvest Technology Center, College of Agricultural Engineering, Bapatla, Andhra Pradesh, India
**College of Agricultural Engineering, Madakasira, India

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com
Received: 18-4-2012
Accepted: 25-5-2012

Key Words:
Improved cook stove
Thermal efficiency
Power rating

ABSTRACT

Approximately 70-80% of the total energy used in villages is consumed for domestic cooking and 80-90% of the domestic energy needs are met through firewood, cow dung and agricultural crop wastes. The bio fuels are being burned in low efficiency traditional cook stoves. The environment within the house is polluted by the smoke emitted from the traditional cook stoves causing ill effect on health of women and children. To alleviate this problem, a number of double pot improved cook stoves (ICSs) have been developed for rural people. Experiments were conducted on different models of cook stoves viz. traditional cook stove, Sukhad, Udairaj and improved Udairaj models to find the thermal efficiency, power rating and specific fuel consumption by conducting water boiling test. Udairaj cook stove was found to have the highest thermal efficiency of 23.4%, whereas traditional cook stove was found to have lowest thermal efficiency of 15.4% among the cook stoves tested. Uadairaj and improved Udairaj cook stoves were found to have similar power rating and lowest specific fuel consumption in the range of 0.811 kw to 0.849 kw and 1.232 kg/kwh to 1.225 kg/kwh respectively whereas traditional cook stove was found to have lowest power rating of 0.559 kw and highest specific fuel consumption of 1.799 kg/kwh.

INTRODUCTION

The traditional cook stoves made of three stone styles and mud are generally used for meeting cooking energy at domestic level. There is no provision for smoke removal in these traditional cook stoves. An improved cook stove is the solid biomass fuel burning system in which heat is produced by combustion for immediate use in domestic cooking. Improved cook stove (ICS) is not only used for increasing thermal efficiency of biomass combustion, but also a means for safe removal of smoke and other inert gases out of kitchen, which are main cause of indoor air pollution. Rathore et al. (1999) observed that on an average 950 kg of fuel wood can be saved through one domestic improved cook stove in a year and revealed that an increase of 1% of thermal efficiency of traditional cook stove could result in saving of energy equivalent to 4 million tons of coal in the country every year. The traditional cook stove used in rural areas has been found unsatisfactory because of its high fuel consumption and pollutants it releases with smoke. To overcome this problem, different models of improved double pot cook stoves have been developed for rural and tribal people. Rathore et al. (2005) evaluated the performance of the Chetak (Single-pot) and Udairaj (Double-pot) cook stoves and the thermal efficiencies of cook stoves were in the range of 20-25% as compared to 8-10% in traditional cook stoves. A study was undertaken with an objective to recommend best cook stove in the rural areas of Andhra Pradesh. Experiments were conducted on different models of cook stoves viz. traditional cook stove, Sukhad, Udairaj and improved Udairaj models to find the thermal efficiency, power rating and specific fuel consumption by conducting water boiling test.

MATERIALS AND METHODS

Construction Details of Cook Stoves

Udairaj cook stove: The fire box is made of bricks laid with cement mortar. An AC pipe of 7.5 cm diameter and 3 m length is used as chimney to create draft for smoke removal and provide sufficient secondary air for combustion. A connecting tunnel is provided for flowing fire from first pot to the second pot. The diameter of the first pot is 24 cm and second pot is 20 cm. The stoves are designed for 1 kg/h wood burning rate (Fig. 1). Table 1 gives the specifications of different cook stoves.

Sukhad cook stove: The stove body measures 80 cm × 42 cm on the floor. Its first platform having fire box is 20 cm high including 3 cm deep pot seat. The second pot hole has raised platform. The diameters of first and second pot holes are 20 cm and 17 cm respectively. The tunnel connecting the pot holes is a pipe piece cut to size from an AC pipe of 7.5 cm diameter and 26 cm long. The tunnel is kept inclined at 30 degrees. This arrangement helps better and direct transfer of heat to the second pot. The chimney tunnel is cut to size from an AC pipe of 5 cm diameter and 13 cm long. To support the chimney pipe (7.5 cm diameter and 3 m long)

Table 1. Major specifications of different cook stoves.

Sl.No	Description	Traditional	Sukhad	Udairaj	Improved Udairaj
1	Body Size, cm	27 × 35 × 22	80 × 42 × 20	80 × 48 × 25	70 × 40 × 22
2	Fire box diameter				
	First pot, cm	-	20	24	18
	Second pot, cm	-	17	20	14
3	Fire box opening				
	Shape	Rectangle	Square	Rectangle	Rectangle
	Size, cm	22 × 17	17 × 17	24 × 16	18 × 16

Table 2: Power rating and specific fuel consumption of different cook stoves.

Stove Model	Average thermal efficiency (%)	Average power rating (kw)	Average specific fuel consumption (kg/kwh)
Traditional	15.4	0.559	1.799
Udairaj	23.4	0.811	1.232
Sukhad	17.89	0.613	1.634
Improved Udairaj	22.2	0.849	1.225

and help its easy replacement and cleaning a separate collared pipe piece 10 cm long (excluding collar) is fixed with cook stove body at the front or rear corner to suit the site (Fig. 2).

Improved Udairaj cook stove: It is similar to that of Udairaj cook stove except that the prefabricated concrete top with first and second pot holes of 18 cm and 14 cm diameter are used to suit the local requirements (Fig. 3).

Traditional cook stove: The traditional cook stove constructed with bricks on three sides with an opening at the front which is commonly used in rural areas is selected for the study (Fig. 4).

Testing of Improved Cook Stove

Water boiling test (WBT): Water boiling test as outlined in the International Standard on testing the efficiency of wood burning stoves, prepared by Volunteers in Technical Assistance (VITA), USA, was conducted for arriving at the overall thermal efficiency of wood burning stove. The water boiling test is a laboratory test, which can be used to compare the performance of two or more stoves under controlled conditions, or the same stove under different conditions. It simulates the boiling/simmering type of cooking to some extent only. As a result it does not necessarily reflects the stove performance, when food is cooked. The experiments were carried out on different days to estimate the efficiency of different stoves.

The fuel wood (*Casuarina*) cut into convenient size, 4-5 cm in diameter and 30-40 cm long is taken from a completely sun dried single lot. Before starting the test, weighed quantity of fuel wood was stacked in small lot of 1 kg each. The fuel wood used is of known calorific value (3500 kcal/kg). The vessels used should fit into the pot hole and sealed properly to avoid leakage. Proper size lids of same material as that of vessels were used to cover the vessels during the test to fit on it without any air gap in between. Known quantity of water was filled into the vessel, so as to occupy its two thirds of volume. Initial temperature of water in both the pots was noted using laboratory (mercury-in-glass) thermometer. The fire was started by igniting small pieces of chopped fuel wood or with minimum (10-15 mL) kerosene. As soon as the fuel wood catches fire in the first pot hole, vessels containing water were placed properly on the pot seats. Temperature rise of water was noted at regular intervals (5 min). The fire was extinguished in the hearth immediately at the end of the test duration and the quantity of residual water in both the pots was measured.

Thermal efficiency, $$E = \frac{H_1 + H_2}{F \times C.V} \times 100$$

Where,

F = Quantity of fuel wood burnt (kg)

C.V. = Calorific value of fuel wood

(3500 kcal/kg for *Casuarina* wood)

H_1 = Sensible heat (kcal)

H_2 = Latent heat (kcal)

E = Thermal efficiency (%)

The power rating of cook stove is the measure of total energy produced during 1 hour by fuel wood.

Power Rating, $$P.R = \frac{F \times C.V \times E}{860} KW$$

Fig. 1: Udairaj cook stove.

Fig. 2: Sukhad cook stove.

Fig. 3: Improved Udairaj Cook stove.

Fig. 4: Traditional cook stove.

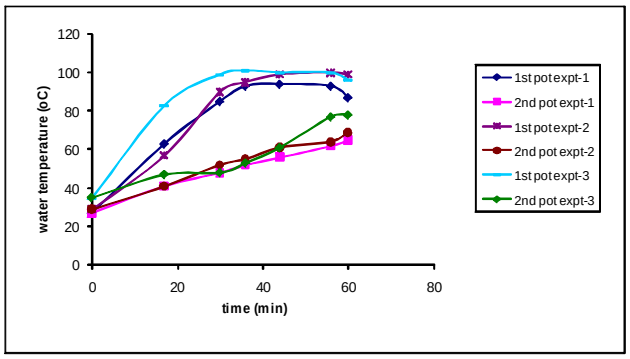

Fig. 5: Variation of water temperature with time in Udairaj cook stove.

Where,

F = Fuel burning rate (kg/hr)

C.V. = Calorific value of fuel wood

(3500 kcal/kg for casuarina wood)

E = Thermal efficiency (%)

RESULTS AND DISCUSSION

Variation of Water Temperature With Time

The water temperature increases with increase in heat input and reaches maximum boiling temperature and then decreases with decrease in heat input. Variation of water temperature with time in each pot of different cook stoves for the burning and recovery periods is presented in Fig. 5 to Fig. 8. From the experimental results it was observed that the variation of water temperature depends on initial water temperature, volume of water taken, prevailing wind conditions and feeding and burning rate of fire wood. Vengatesan et al. (1991) made similar observations on a high efficiency smokeless wood burning stove.

Thermal Efficiency of Different Cook Stoves

From the experimental results Udairaj stove was found to have highest average thermal efficiency of 23.45% and traditional stove was found to have lowest averaged thermal efficiency of 15.4% (Fig. 9). The reasons for low thermal efficiency with traditional cook stove are perhaps heat losses and low conservation of heat due to only one pot. Rathore & Jain (2001) made similar observations on "Chetak" and "Udairaj" models of improved cook stoves.

Power Rating and Specific Fuel Consumption of Different Cook Stoves

Improved Udairaj cook stove was found to have the highest average power rating of 0.849 kw and lowest average specific fuel consumption of 1.225 kg/kwh in comparison to lowest power rating of 0.559 kw and high specific fuel consumption of 1.799 kg/kwh with traditional cook stove (Table 2). It was observed that with increase in thermal efficiency, the power rating increases as the stove output increases and specific fuel consumption decreases. Similar observations were made by Maiti & Gupta (1993) on "Aravali" improved unified chulha at Central Glass & Ceramic Research Institute, Khurja, U.P.

CONCLUSIONS

Based on the experimental data and results, Udairaj cook stove was found to have the highest thermal efficiency of 23.4% whereas traditional cook stove was found to have low-

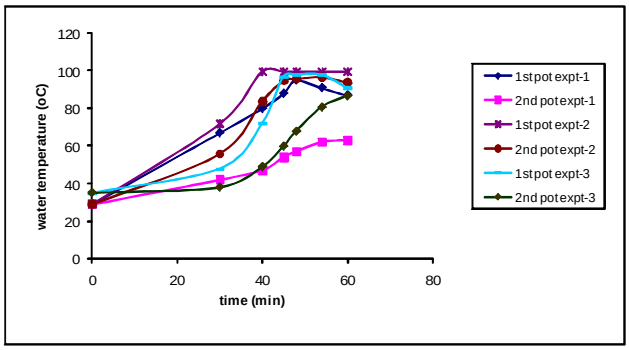

Fig. 6: Variation of water temperature with time in Sukhad cook stove.

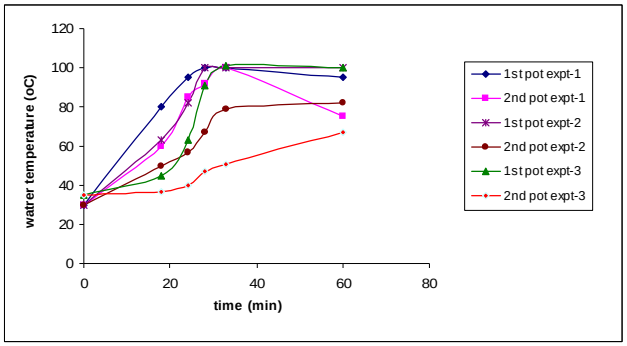

Fig. 7: Variation of water temperature with time in improved Udairaj cook stove.

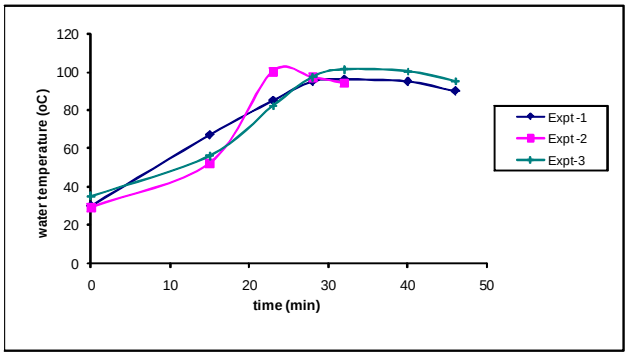

Fig. 8: Variation of water temperature with time in traditional stove.

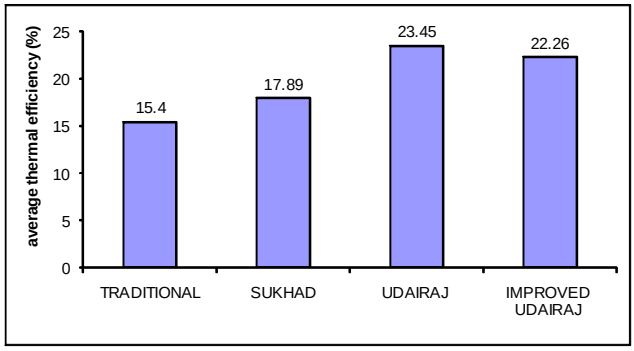

Fig. 9: Average thermal efficiency of different cook stoves.

est thermal efficiency of 15.4% among the cook stoves tested. Uadairaj and improved Udairaj cook stoves were found to have similar power rating and lowest specific fuel consumption in the range of 0.811 kw to 0.849 kw and 1.232 kg/kwh to 1.225 kg/kwh respectively whereas traditional cook stove was found to have lowest power rating of 0.559 kw and highest specific fuel consumption of 1.799 kg/kwh. Overall, it was found that, although both Udairaj and improved Udairaj cook stoves are better than traditional cook stove in terms of thermal efficiency, power rating and specific fuel consumption, improved Udairaj model stands out as it is easy to construct due to prefabricated concrete top used for the installation.

REFERENCES

Chandel, S. S., Aggarwal, R. K. 1993. Identification of design parameters of traditional cook stoves of Himachal Pradesh. ANTIKA, a publication on Improved Chulha, 4: 15-20.

Garg, B.M.L. and Jagwani, S.K. 1993. Development of low cost metal-clad ceramic/refractory lined chulhas (New Generation Chulhas). ANTIKA, a publication on Improved Chulha, 4: 8.

Karthikeyan, G., Balakrishna Reddy, K., Sethumadhavan, R. and Vasudevan, R. 1991. Low cost high efficiency mud stove for domestic cooking. Technical Paper Presented at IIT, Madras, pp. 49-52.

Khuntia, S. 1993. Development of multi feed cook stove. ANTIKA, a publication on Improved Chulha, 4: 82-88.

Mati, K.N. and Gupta, A.K. 1993. Thermal performance of 'Aaravali' improved unifed chulha under different experimental conditions. ANTIKA, a publication on Improved Chulha, 4: 55-64.

Rathore, N.S., Paneri, K.L. and Rajesh Meena 1999. Improved Cook Stoves for Minimization of Indoor Air Pollution and Energy Conservation. Project Implemented by Maharana Pratap University of Agriculture and Technology, Udaipur, Rajastan.

Rathore, N.S. and Sudhir Jain. 2001. Durable improved cooking stoves for rural and tribal families. Agricultural Engineering Today, 25: 47-52.

Rathore, N.S., Kurchania, A.K., Sudhir Jain, Mathur, A.N. 2003. Durable Improved Cook Stoves. All India Co-ordinated Research Project on "Renewable Sources of Energy", Central Institute of Agrcultural Engineering, Bhopal.

Rathore, N.S. and Sudhir Jain 2005. Durable and improved cooking stoves for rural areas. Agricultural Engineering Today, 29: 1-2.

Vengatesan, S., Nagabushana Raju, K., Sethumadhavan, R. and Vasudevan, R. 1991. High Efficiency Smokeless Wood Burning Stove. Technical paper presented at Entrepreneurship Development Programme at IIT, Madras, pp. 43-47.