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Performance assessment of improved version of cook stoves

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Abstract **:** Biomass is the organic matter produced by plants. Incomplete combustion of biomass fuel generate high levels of indoor pollutant gases like CO, NO_2, SO_2, Sulphur oxides etc. A modified version of the traditional cook stoves is the improved cook stove in which the biomass is burnt more efficiently with respect to fuel consumption, thermal efficiency and also makes them convenient for cooking and much safer from a health point of view. The thermal efficiency of single pot Chetak and double pot Udairaj improved cook stoves was 23.34 and 24.30 per cent, respectively as compared to that of 12.20 per cent for traditional cook stove. The combustion efficiency of single pot Chetak and double pot Udairaj improved cook stoves were 62.3 and 81.8 per cent, respectively while it was 56.4 per cent for traditional cook stove. So it is concluded that the improved cook stoves are more efficient than traditional cook stoves for thermal applications.

Key words **:** Biomass, Thermal efficiency, Improved cook stoves

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The majority of the households in the developing countries like India, use biomass fuels such as wood, dung and other fibre residues on a daily basis for cooking and heating (World Resources, 1998). Smoke from biomass combustion contains high levels of indoor pollutants which may be harmful to the health of the exposed individuals. India bears one of the largest burdens of disease due to the use of unclean household fuels (Smith *et al.,* 2000). The exposure was found to be highest in women and young children groups in both rural and urban groups of developing countries. Rathore and Jain (2001) developed single and double pot improved cook stoves for rural and tribal people. They reported that the thermal efficiency of these improved cook stove was in the range of 21.78 – 29.08 per cent. Spautz *et al.* (2006) reported that the parameters like thermal efficiency, combustion efficiency, concentration of carbon monoxide and carbon dioxide are the main criteria for evaluating the performance of cook stoves. Desai *et al.* (2007) studied the adoption of improved cook stoves by rural women of Raichur region. They reported that the thermal efficiency of Udairaj improved double pot cook stove varied from 24-26 per cent as compared to 10-12 per cent for traditional cook stoves. The power output rating of the improved cook stoves was 1.42 kW while it was 0.98 kW for traditional cook stoves.

METHODOLOGY

Constructional details of cook stoves:

Single pot chetak cook stove:

The single pot chetak cook stove was constructed using cement, brick and sand. The dimensions and specifications are given in the line diagram shown in Fig. A.

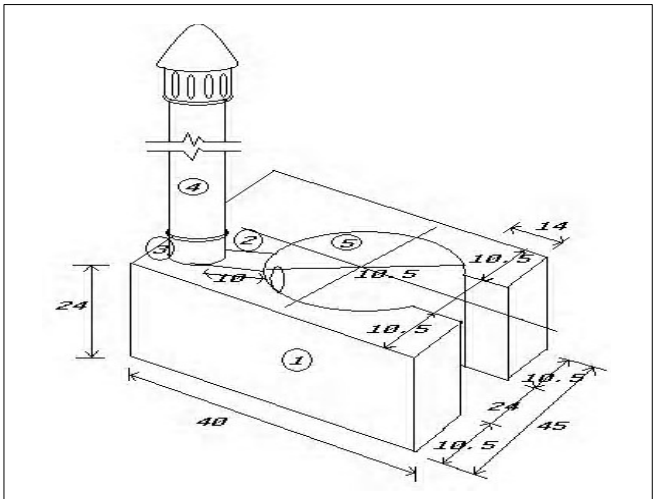

Fig. A : Single pot Chetak cook stove

Double pot udairaj cook stove:

The double pot Udairaj cook stove was constructed using cement, brick and sand. The dimensions and specifications are given in the line diagram shown in Fig. B.

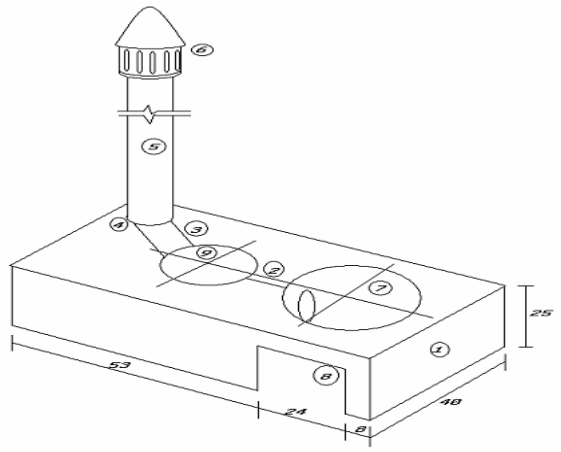

Fig. B : Udairaj double pot cook stove

Traditional cook stove:

The traditional cook stove was constructed using clay with water manually. The size can be adjusted as per the requirement.

Thermal efficiency:

It is defined as the fraction of the heat utilized to the heat supplied by the fuel and is calculated as follows:

Thermal efficiency = (Heat output/ Heat input)*100

Heat output is given by,

Ho = ms^ t + L m

where,

m= Mass of water taken, kg; s= Specific heat of water, kcal / kg ^{0}C; t= Temperature difference, (t_1-t_2), ^{0}C; L= Latent heat of water, kcal / kg; m= Loss in weight of water, kg

Heat input is given by,

Hi = M x CV

where,

M = Mass of fuel, kg; CV= Calorific value of fuel, kcal / kg

Heat input is given by,

Hi = M x CV

where,

M = Mass of fuel, kg; CV= Calorific value of fuel, kcal / kg

Power output rating:

It is the rated power that is generated by the cooking device. The power output rating (PR) was calculated as given below:

PR= F*CV*N/ (860*100), kw

where

F= Quantity of fuel burnt, kg/hr; CV= Calorific value of fuel, kcal/kg; N= thermal efficiency of stove, per cent

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussion have been summarized under following heads:

Performance of cook stoves in general:

It was observed that the quantity of biomass (wood) burnt was 0.85 kg / hr in single pot while 1.30 kg/hr in double pot cook stove, whereas 1.20 kg/hr of biomass was burnt in traditional cook stove. It was observed that the thermal efficiency of single pot and double pot improved cook stoves was 23.34 and 24.30 per cent, respectively as compared to that of 12.20 per cent for traditional cook stove. The power output rating of single pot and double pot improved cook stoves was 0.92 and 1.47 kW, respectively as compared to that of 0.68 kW for traditional cook stove (Table 1 and Fig. 1).

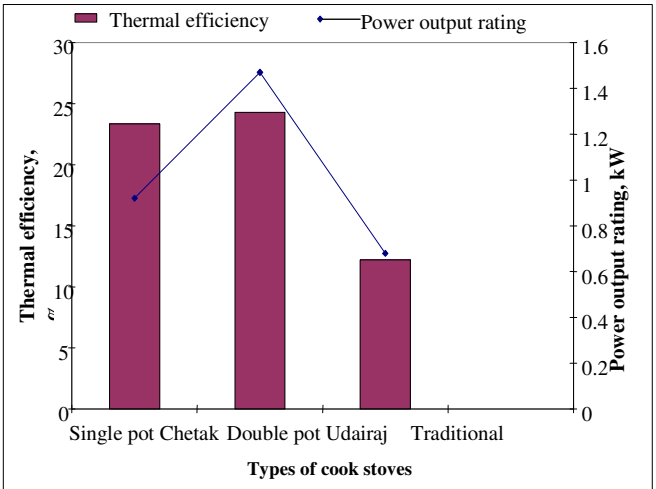

Fig. 1 : Performance of improved cook stoves using thermal efficiency

Performance of improved cook stoves for thermal applications:

The performance of improved cook stoves for thermal applications was evaluated in terms of cooking of rice and dhal and compared with traditional cook stove. It was observed

Table 1: Performance of single pot and double pot improved cook stove

Types of cook stoves	Qty. of water taken (l)	Qty. of biomass burnt. (kg)	Time taken for boiling (min)	Initial temp. of water (^{0}C)	Final temp. of water (^{0}C)	Amount of water evaporated (ml)	Thermal efficiency (%)	Power output rating kW
Single pot Chetak	1	0.85	16	32	98	175	23.34	0.92
Double pot Udairaj	1	1.30	14	32	98	195	24.30	1.47
Traditional	1	1.20	18	32	98	160	12.20	0.68

Table 2 : Flue gas analysis for the different cook stoves

Sr. No.	Type of cook stove	Flue gas temp (^{0}C)	O_2 (%)	CO (ppm)	CO_2 (%)	NOX (ppm)	SO_2 (ppm)	PI	Combustion efficiency, (%)
1.	Single pot Chetak cook stove	110	16	1355	3.5	86	135	5.68	62.3
2.	Double pot Udairaj cook stove	130	14.5	1230	4.8	95	145	4.50	81.8
3.	Traditional cook stove	95	19.7	1570	5.5	102	158	6.12	56.4

that the time required for cooking of rice in single pot chetak cook stove and double pot Udairaj cook stoves was 22 and 20 minutes, respectively while it was 25 minutes in traditional cook stove. Further, it was observed that the time required for cooking of dhal in single pot Chetak cook stove and double pot Udairaj cook stoves was 35 and 32 minutes, respectively while it was 40 minutes in traditional cook stove (Fig. 2).

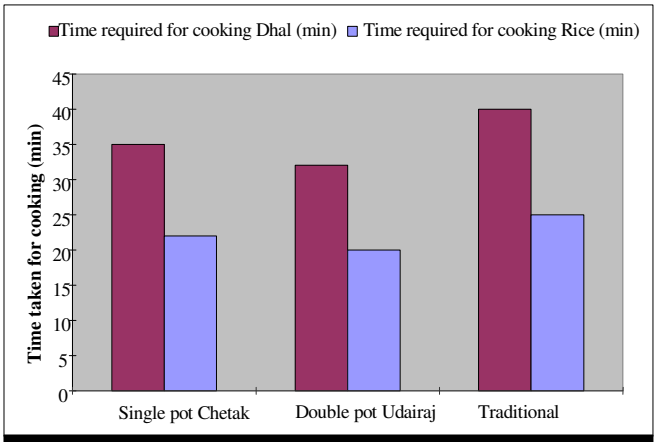

Fig. 2 : Performance of improved cook stoves for cooking dhal and rice

Flue gas analysis:

The flue gas emitted by different improved cook stoves was analyzed using standard flue gas analyzer. For traditional cook stove the CO recorded was 1570 ppm, whereas for the single pot and double pot improved cook stoves observed was 1355 and 1230 ppm, respectively. Similarly the Poisson index value of single pot and double pot improved cook stoves were observed to be 5.68 and 4.50, respectively which is less than as compared to that of traditional cook stove (6.12). (Table 2). It was observed that the combustion efficiency of single pot and double pot improved cook stoves were 62.3 and 81.8 per cent, respectively while it was 56.4 per cent for traditional cook stove which indicated that the improved cook stoves burned the biomass more efficiently than the traditional cook stoves.

Conclusion:

The modified version of the traditional cook stoves *viz*., single pot Chetak cook stove, double pot Udairaj cook stove were found to be more efficient with respect to fuel wood consumption, thermal efficiency, making them more convenient and safer for several thermal applications. Also they helped in reducing indoor air pollution which in turn avoids the serious health hazards of exposed individuals.

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