ENGINEERING AND TECHNOLOGY IN INDIA
Volume 3 | Issue (1) | April, 2012 | 20-23

RESEARCH ARTICLE

Performance evaluation of improved 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 efficient 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 MS rod was 23.80 per cent while it was 24.10 per cent for the cook stove made of GI wire and 24.30 per cent for the cook stove made of perforated stainless steel as compared to that of 12.20 per cent for traditional cook stove. The combustion efficiency of husk cook stove with central fire port made of stainless steel perforated mesh was highest (74.10 %) as compared to 71.3 and 70.8 per cent for that of GI wire and MS rod, 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, Combustion efficiency, Traditional cook stoves, Fuel consumption

How to cite this Article : Mahawar, Manoj (2012). Performance evaluation of improved cook stoves. *Engg. & Tech. in India,* **3**(1&2) : 20-23

Article Chronicle : Received : *13.10.2011;* **Revised :** *01.12.2011;* **Accepted :** *02.02.2012*

INTRODUCTION

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. Laura 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.

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EXPERIMENTAL PROCEDURE

Fabrication of husk cook stove:

A cylinder of 20cm diameter with 17cm height was fabricated using 22 gauge MS perforated mesh. A cone shape structure of 34cm top diameter and 20cm base and height of 15cm was fabricated using 22 gauge GI sheet. This was welded to the perforated MS cylinder. A grate of diameter 20cm made up of 20gauge MS perforated sheet was fixed at the bottom of the stove on which the ash will be collected. In order to hold the cook stove a stand was fabricated using 2/8" MS rod to which 3 legs made up of MS flat of 1"X1/8" were welded. Three different central fire ports were fabricated as explained below:

Husk cook stove with central fire port made up of MS rod:

Two numbers of circular rings of 9cm diameter were made

using 6mm MS rod. Then 6mm rods of 30cm length were welded in between these two rings in order to form a cylindrical mesh of 9cm diameter and 30 cm height. After fabrication of new central fire port mesh with MS rod, this was welded at the centre of the husk cook stove. The rice husk cook stove with central fire port mesh made of MS rod is shown in Fig. A.

Fig. A : Husk cook stove with central port made up of MS rod

Husk cook stove with central fire port made up of GI wire:

Two numbers of circular rings of 9cm diameter were made using 6mm MS rod. Then GI wire was cut into number of pieces of 30cm length each and welded in between these two rings in order to form a cylindrical mesh like structure of 9 cm diameter and 30 cm height. After fabrication of husk central fire ports with GI wire, this was welded at the center of the husk cook stove. The rice husk cook stove with central fire ports mesh made of GI wire is shown in Fig. B.

Fig. B : Husk cook stove with central port made up of GI wire

Husk cook stove with central fire port made up of stainless steel mesh:

Two numbers of circular rings of 9cm diameter were made using 6mm MS rod. Then stainless steel perforated mesh was brazed in between these two rings in order to form a cylindrical mesh like structure of 9cm diameter and 30 cm height. After fabrication of new central fire port with stainless steel mesh, this was welded at the centre of the husk cook stove. The rice husk cook stove with central fire port mesh made of stainless steel mesh is shown in Fig. C.

Fig. C : Husk cook stove with central port made up of stainless steel

Performance evaluation of cook stoves:

The performance of all the cook stoves was evaluated in terms of thermal efficiency and power output rating using water boiling test. A known amount of husk has been taken and mixed with known quantity of water thoroughly. This mixture is been filled in all the 3cookstoves up to the maximum level by compacting it using the iron rod or wooden stick. Further a little mass of burnt wood is kept inside the hole to lighten the stove easily for the experiment. Initially a known quantity of water is kept in vessels in all the 3 stoves and the initial temperature is recorded. Mean while during the burning process temperature of water is observed for attaining the higher temperature. The time taken for water boiling up to the highest temperature had been recorded for all the 3 cook stoves.

Parameters recorded during the experiment:

Temperature:

The initial and final temperatures of water during the

experiment were measured using standard thermometer of accuracy 1^0C .

Quantity of water:

The quantity of water taken and also the quantity of water remained in the vessels were measured using a measuring flask of 500 ml capacity.

Quantity of biomass:

The quantity of biomass was measured using weighing balance of accuracy 1 g.

Time taken for the boiling:

Time taken to reach boiling point of water in different cook stoves was recorded using a stop watch.

Amount of water evaporated:

The amount of water evaporated was calculated by subtracting the quantity of water remained after complete combustion of the biomass to the initial quantity of water taken.

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 * 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/h

CV= Calorific value of fuel, kcal/kg

N= thermal efficiency of stove, per cent

Analysis of flue gas:

The flue gas was analyzed for its different constituents using standard Flue Gas Analyzer Model KM 900 Plus.

EXPERIMENTAL FINDINGS AND ANALYSIS

It was observed that the quantity of biomass (husk) burnt was 1.7 kg / h in all MS rod, GI wire and stainless steel husk cook stoves and the time taken by the water to boil was lowest (20mins) in the cook stove made up of stainless steel mesh. Thermal efficiency and power output rating of husk cook stoves is given in Table 1 and shown in Fig. 1. The thermal efficiency of the cook stove made of MS rod is observed to be 23.80 per cent, for the cook stove made of GI wire it was 24.10 per cent and for the cook stove made of perforated stainless steel it was 24.30 per cent. It was observed that the power output rating of the cook stoves was at par with each other. The results are tabulated in Table 1 and the graph showing the results has been presented as Fig. 1.

Flue gas analysis:

The flue gas emitted by different improved cook stoves was analyzed using standard flue gas analyzer. The different constituents of flue gas emitted by the husk cook stoves are

Table 1 : Performance of husk cook stoves

Types of husk cook stoves	Power output rating, kW	Quantity of water taken (litre)	Quantity of husk burnt. (kg)	Quantity of wood consumed (kg)	Time taken for boiling (min)	Initial temperature of water (°c)	Final temperature of water (°c)	Amount of water evaporated (ml)	Thermal efficiency, %
MS rod	5	1.7	0.5	30	26	97	1100	23.8	1.02
GI wire	5	1.7	0.5	25	26	97	1250	24.10	1.03
Stainless Steel	5	1.7	0.5	20	26	97	1300	24.30	1.04

Table 2 : Analysis of flue gas of husk cook stoves

Sr. No.	Type of husk cook stove	Flue gas temp. (^{0}C)	O_2 (%)	CO (ppm)	CO_2 (%)	NO_x (ppm)	SO_2 (ppm)	PI	Combustion efficiency, (%)
1.	MS rod	164	19.2	1490	0.066	73	3.4	5.68	70.8
2.	GI wire	168	19.4	1498	0.069	71	3.5	4.50	71.3
3.	Stainless steel	175	19.6	1500	0.068	75	3.3	6.12	74.1

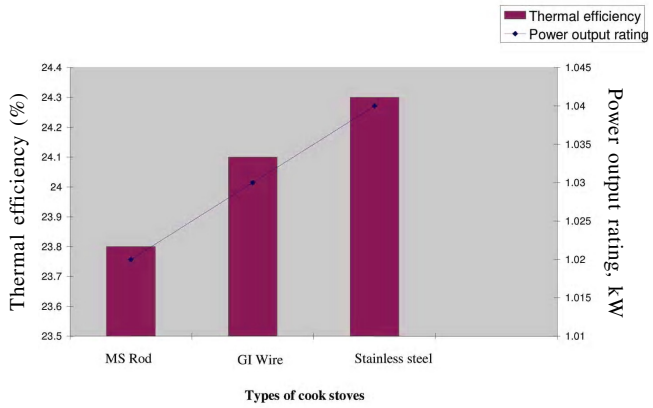

Fig. 1 : Performance of husk cook stoves using thermal efficiency

presented in Table 2.

It was observed that the CO and CO_2 concentration of the husk cook stoves were at par with each other as the cook stove fabricated are of same design and the biomass material used is also same. It was observed that the combustion efficiency of husk cook stove with central fire port made of stainless steel perforated mesh was highest (74.10 %) as compared to 71.3 and 70.8 per cent for that of GI wire and MS rod, respectively while it was 56.4 per cent for traditional cook stove which indicated that the improved cook stoves burn the biomass more efficiently than the traditional cook stoves.

Conclusion:

The modified version of the traditional cook stoves *viz.* husk cook stove with central fire port of MS rod, GI wire and stainless steel perforated was 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 help in reducing indoor air pollution which in turn avoids the serious health hazards of exposed individuals.

Acknowledgement:

The author thanks for the Department of Farm Power Machinery, University of Agricultural Sciences, Raichur (Karnataka), INDIA.

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