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IMPROVEMENT OF THE EFFICIENCY OF TRADITIONAL CHULA

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ABSTRACT

A series of experiments were conducted to findout the best dimension combination of the 4-hole type Traditional chula with the aim of obtaining maximum heat utilisation efficiency (HUE). Four dimension parameters were considered in the experiment, such as, hearth diameter, hearth height, mouth diameter and hole area. The effect of these parameters on the HUE was also tested statistically.

Experiments were carried out on 4 different sizes of chula. Dimension combination was found different for different sizes of chula at maximum efficiency. Maximum HUE was 21.55, 21.54, 25.05 and 24.4% for the hearth diameter of 180, 220, 260 and 300 mm rorpectively.

Key words : Traditional Chula, Heat, Efficiency

INTRODUCTION

Biomass is the main source of energy of Bangladesh. BEPP (1981) report shows that abouf 81.7% of total energy consumption comes from Biomass. Again 80% of the total biomass energy is consumed for cooking (World Bank. 1982). Rural people mainly use the traditional chula (earthen device) for cooking. The efficiency of these chula is from 5 to 11% (Makhijani, 1977 ; Siwatibau, 1978 ; Islam, 1980 ; Khan, 1989 & Alam, 1990). The use of these low efficient chula is the main cause of high consumption of biomass fuel for cooking.

Many researchers worked to design and develop improved chula. Many types and models of chula are now available in the world having efficiency from 20 to 40% (Islam, 1980 , Prashad, 1987 & Khan, 1989). Many organisations are trying to dissiminate the improved stove. But their success is very limited (Islam, 1980). The reasons for the failure of improved stove dissimination are high construction cost, unavailability of construction material and skilled labourer in the rural areas and limitation of the type of biomass fuel used in the improved stove.

Hossain et. al. (1991) reported that mainly two types of traditional chula were available in the rural areas : One 3-stone type and the other 3-hole type. They also reported that dimension parameter has the significant effect on the HUE. Therefore, to

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improve the efficiency this research work is undertaken to select the best dimension combination of 4-hole type chula.

METHODOLOGY

Four 4-hole type chulas (Fig. 1) were made with clay soil having hearth diameter (D) of 180, 220, 260 and 300 mm. For each sizes other dimension parameters such as hearth height (H), mouth diameter (d) and hole area (ha) were varied for the determination of heat utilisation efficiency (HUE). H varied from 300 to 450 mm at the interval of 50 mm and d varied from 100 to 140 mm at the interval of 20 mm and 3 hole areas were chosen for the experiment such as 1120, 1620 and 2530 mm². For each set of dimension combination HUE was determined and each experiment replicated thrice.

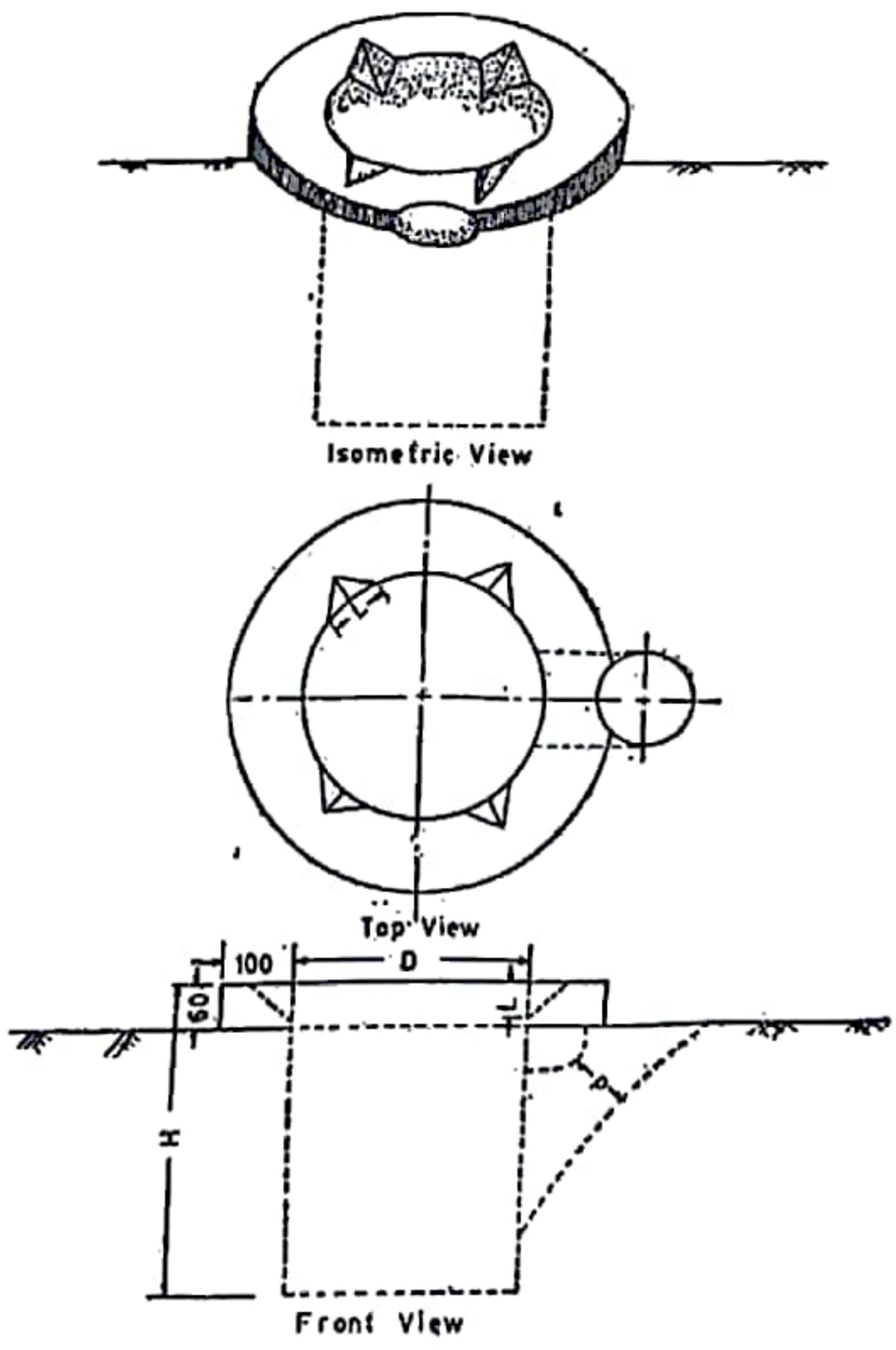

Fig. 1, Hole type Chula, D = Hearth diameter, d = Mouth diameter, H = Hearth height, ha = $\frac{1}{2}LL_1$ = hole area (Dimen sions are in mm)

in the experiment round bottom aluminum pan of diameter 1.3 times higher than that of hearth was used. Mango wood of uniform size was used as fuel and uniformity was maintained during the feeding of fuel in the chula.

The HUE of the chula was measured by water boiling method using the following formula :

$$HUE = \frac{\text{Heat output}}{\text{Heat input}} \times 100$$

$$= \frac{(W_w C_w + W_u C_u)(T_f - T_i) + W_{ev} L}{W_f C_f - W_c C_c} \times 100$$

where. W_w = Weight of water taken in the utensil, kg.

W_u = Weight of utensil, kg.

C_w. C_u = Specific heat of water and utensil respectively, kJ/kg. °C.

W_{ev} = weight of water evaporated, kg.

L = Latent heat of Vaporisation, kJ/kg.

W_f = Weight of fuel used, kg.

W_c = Weight of charcoal remained after completion of the experiment, kg.

C_f . C_c = Calorific value of fuel wood and charcoal respectively, kJ/kg.

T_i . T_f = Initial and final temperature of water respectively, °C.

About three quarters of the pan was filled with water and heated for one hour. Temperature was recorded with mercury thermometer and weight was measured by balance.

Statistical analysis was carried out to test the effect of dimensions on the HUE by the 3-factors complete randomised block design (CRBD).

RESULTS AND DISCUSSION

The observed HUE of the chula for all possible dimension combination is presented in Table 1. The HUE varied from 11.6 to 25% depending on the dimension combination. The maximum HUE was found different for different sizes of chula. It was 21.55. 21.54. 25.05 and 24.4% for the hearth diameter size of 180. 220. 260 and 300 mm. respectively. Again for different sizes it did not occur at the same dimension combination of H. d and ha except for the D of 260 and 300 mm. In case of smaller chula maximum HUE was observed at low H. d and ha but for larger chula it occured at higher H. d and ha. Out of 4 chulas highest HUE was found with hearth diameter of 260 mm. Razzaque (1992) also found maximum HUE with this size of chula of 3-stone type.

The HUE in 4-hole type chula was found much more higher than 3-stone type traditional chula. Islam (1980) reported that 3-stone type chula has the maximum HUE of 14% for hot start condition. Here 4-hole type gave maximum HUE of 25% which is

Table 1. Average HUE of all dimension conbination

Hearth dia D mm	Mouth dia d mm	Hearth ht. H mm	Efficiency, % Hole area (ha) mm² 1120	1620	2530
		300	21.55	20.23	16.20
	100	350	18.02	15.88	16.47
		400	18.15	17.04	14.71
		300	13.64	18.52	13.45
180	120	350	18.03	11.64	15.73
		400	17.44	14.82	14.71
		300	13.52	12.93	15.00
	140	350	14.27	14.44	15.10
		400	18.70	13.37	11.75
		300	18.00	21.54	16.16
	100	350	18.31	17.17	17.20
		400	15.32	14.21	16.20
		300	18.65	20.30	17.57
220	120	350	20.86	17.43	15.00
		400	20.85	20.00	17.33
		300	20 C0	18.71	18.00
	140	350	19.30	16.56	21.12
		400	19.83	16.94	15.19
		350	19.00	16.85	17.16
	100	400	18.42	17.36	16.37
		450	18.00	17.00	15.15
		350	14.91	22,48	15.30
260	120	400	24.00	25.05	19.10
		450	21.19	22.35	15.83
		350	19.37	16.52	17.45
	140	400	20.58	21.37	16.00
		450	18.00	17.70	12.16
		350	19.87	21.08	19.57
	100	400	18.00	22.53	17.34
		450	17.30	20.25	16.23
		350	20.84	23.16	16.23
300	120	400	22.04	24.40	17.29
		450	20.67	23.05	17.01
		350	20.43	19.00	16.00
	140	400	23.36	15.26	19.72
		450	21.29	16.60	18.72

almost double than that of 3-stone type. This maximum HUE is only possible for particular dimension combination if not this 4-hole type can produce HUE less than 14% (Table 1).

The farmers will select the size of chula on the basis of their family size. Therefore, best dimension combination was determined for different sizes of chula from 180 mm to 300 mm diameter. For heatth diameter of 180 mm, HUE was found maximum at H=300 mm d=100 mm and ha = 1120 mm² whereas for D=260 mm HUE was, maximum at H=400 mm d=120 mm and ha= 1620 mm² (Table 1).

HUE was low at maximum ha=2530 mm², it may be attributted to the heat loss through largo hole area as flue gas. Also at highest H=450 mm HUE was never found to attain maximum, it may be due to the long distance between the pan bottom and the the flame.

The effect of dimensions such as H, d and ha on HUE for all sizes of chula were tested statistically. The effect of all possible combination was found significant at 5% level of significance.

The occurance of maximum efficiency at the different dimension combination for different sizes of chula justifies the need of optimum air supply to the chula, flue gas passage and distance between the pan and the flame. For complete combustion of 1 kg of wood, 5 kg of air is needed (Molle, 1982). Less supply of air will create incomplete combustion and more supply will cause heat loss to the surroundings. Therefore, an optimum dimension must be ensured in the design of chula to get maximum efficiency.

The use of this zero cost chula with proper dimension will decrease the fuel consumption to less than half, therefore neccessary steps are needed to be taken for its dissimination.

CONCLUSION

The change of dimension parameter of the 4-hole type chula has the significant effect on the HUE. The HUE varied from 11.6 to 25% depending on the variation of the dimension parameter. Maximum HUE was found to be 21.55, 21.54, 25.05 and 24.4% for the sizes of 180, 220, 260 and 300 mm hearth diameter, respectively. The best dimension combination giving maximum HUE are as follows : (D=180 mm H=300 mm, d=100 mm, ha=1120 mm²), (D=220 mm, H=300 mm, d=100 mm ha=1620 mm²), (D=260 mm, H=400 mm, d=120 mm, ha=1620 mm²) and (D=300 mm, H=400 mm, d=120 mm and ha=1620 mm²).

At the higher H, d and ha HUE was observed to be decreasing.

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