# A NEW FUEL EFFICIENT BATH ROOM STOVE

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## Abstract

Design and development of a new fuel efficient wood burning bath room stove is described here. Fuel efficiency of the new stove is 40 %. This is much higher than the conventional bath room stoves which have only 15 % efficiency. The new stove is installed in Unchagi, a village in Uttara Kannada and saving of fuel over 60 % is demonstrated.

## 1. Introduction

It is commen knowledge that people in India do take hot water bath. Most people of Uttara Kannada district in Western Ghat region of Karnataka take hot water bath once a day. Out of 363 people of one village Unchagi in Uttara Kannada, 300 are taking bath once a day and rest take bath atleast twice a week. Bath water temperature varies from 38° to 46°C and the quantity varies from 20 to 40 litres per person. Traditionally, water is heated in a round copper vessel of 50 to 70 litres capacity. Nature of fuel varies from region to region and mainly wood, twigs , shrubs and agricultural residues such as arecanut husk, coconut husk, and palm leaves are used. A priliminary study of fuel requirement for bath water heating carried out for Unchagi showed that about 1 kg of fuel is required per person per day and that for cooking it is about 1.25 kg per person per day. No family used electricity or even biogas for bath water heating. A study of domestic fuel consumption pattern for a cluster of villages around Ungra in Tumkur district of Karnataka by Reddy et al[1] showed that fuel is mostly used for cooking and heating water for bath consumes very little fuel due to infrequent bathing habits. However, for people of Western Ghat region such as of Uttara Kannada, hot water bath is a ritual and fuel

required for this is about the same as that for cooking.

While there /have been several efforts at improving domestic cook stoves to conserve fuel[2,3], there /has been almost no study to improve the bath water heating stove using vegetative fuel. People of Uttara Kannada have been enquiring if conservation of fuel is possible through an improved design in the light of their good experiences with an improved community jaggery unit[2] and a 3 pot wood burning stove, ASTRA CLE[3,4]. Therefore, a study on the improvement of bath water heating stove was taken up.

In traditional stoves, fuel is laid on the floor below the vessel and fired. The rate of burning entirely depends upon the ratio of surface area to volume of the fuel; shrubs, palm/burn leaves fast whereas cut wood of higher diameter burns slowly. There is no control of air which is required for combustion. Mixing of air with the fuel is very poor in these stoves and hence more smoke containing organic volatiles come out which give burning sensation to the eye. Also, excess air surrounding the fuel brings down the temperature of the flame and hence the stove is less efficient.

Controlled combustion of fuel to extract maximum heat is in practice in the boilers of industrial applications,

/efficiency upto 70 %, where is achieved. This principle was first used for rural applications in a community jaggery unit using bagasse as fuel[2]. Here, bagasse is burnt over a cast iron grate and the flue gas generated is used to heat more juice in the second and third pans and finally it is left through a chimney. Air inlet was controlled through windows provided below the grate. 60 % heat efficiency was achieved. Based on the same concept, a three pot wood burning/cooking stove has been developed by Kumar et al[3,4] where 45 % efficiency is achieved.

In this report, design of a new, single pot, bath room stove based on the principle of controlled combustion is described. Working of this has been demonstrated at Unchagi village. Efficiencies of existing bath room stoves have been examined. Compared to only 15 % efficiency observed in the conventional bath room stoves, 40 % efficiency has been achieved in the new stove. Fuel saving of over 60 % has been realised.

## 2. Materials and Methods

### 2.1. Efficiency

Efficiency of a stove is estimated by water heating test. Heat gained by a known / amount of water is measured by burning a measured quantity of wood. For these

experiments, casurina cut wood sun dried over 20 days is used. Calorific value of the wood used is 3800 k cal/kg. The efficiency is obtained as follows:

$$\% \text{ heat utilization (PHU)} = \frac{(\text{wt. of water in kg}) \ (\Delta T)}{(\text{wt. of wood burnt in kg}) \times (3800)} \times 100$$

where $\Delta T$ is the rise in temperature. In traditional bath rooms charcoal is not collected back; therefore, complete burning was allowed in our experiments. Highest temperature attained was recorded for a given amount of wood burnt. Evaporation of water was not allowed by keeping the vessel covering with a lid. Generally, water was heated from room temperature (25 to 30°C) to 55 to 60°C in our experiments.

## 2.2. Design contraints of the new stove

Our survey of bath room stoves in selected villages taken up for detailed study of ecosystem development of Western Ghats viz. Unchagi, Bhairumbe, Bengle-Onikere and Masur in Uttara Kannada showed that only a single vessel is used in bath rooms for water heating. Accordingly, the following constraints were taken into account while designing the new stove. They are:

(a) Only a single vessel of the type which are presently used be adapted in the new stove. This means

a round bottom copper vessel of 50 to 70 litres capacity be used in the new stove.

(b) Locally available material be used for constructions.

(c) Stove be easy to construct, smoke less, easy to light and easy to extinguish.

(d) Rate of burning be such that in about 30 min., 50 to 60 litres of water be heated to 50°C so that water is ready for bath.

(e) Cost shall be kept at a minimum.

## 2.3. Materials for construction

In Uttara Kannada, lattrite stone of 23 cm x 37 cm x 37 cm is available. Otherwise, bricks, burnt or unburnt can be used. The materials required for construction are given below:

| | Materials | Quantity |
|---|---|---|
| a. | Stones(Lattrite) | 20 |
| | or | |
| | Bricks | 200 |
| b. | Cast ion grate | 20cm x 20cm(one) |
| c. | Asbestos cement pipe for chimney | 10cm inner dia, 3m height, (one) |

| | | |
|---|---|---|
| d. | Lid for fuel box | 60cmx30cm, G.I. sheet (one) |
| e. | Rice husk or saw dust | 3-4 buckets of 15 liter capacity |
| f. | Mud for plastering and construction (sieved) | 3-4 buckets of 15 liter capacity |

For plastering in the top area, cement can also be used so that water falling over it will not spoil the furnace.

## 3. Results

### 3.1. Conventional bath room stoves

A survey of bath room stoves in typical villages, Unchagi, Kotegudde and Bhairumbe of Uttara Kannada showed that no family used more than one vessel for heating water in bath room. Mainly 4 types of bath room stoves, A, B, C and D are found in these area. These are shown in figs. 1 to 4. Efficiencies of each of these 4 type stoves were measured by water boiling test. The approximate percentage occurrence and their efficiencies are given in Table 1.. Typical bath room stoves are illustrated in figs. 5 and 6.

As can be seen from Table 1, fuel efficiencies increase with degree of sophistication. The stove with a chimney gave 22 % efficiency. However, very few families have bathrooms with chimney . No bath room had a grate of any type over which fuel is burnt.

A

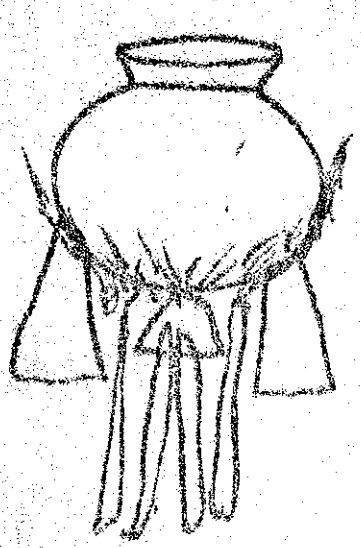


FIG 1

B

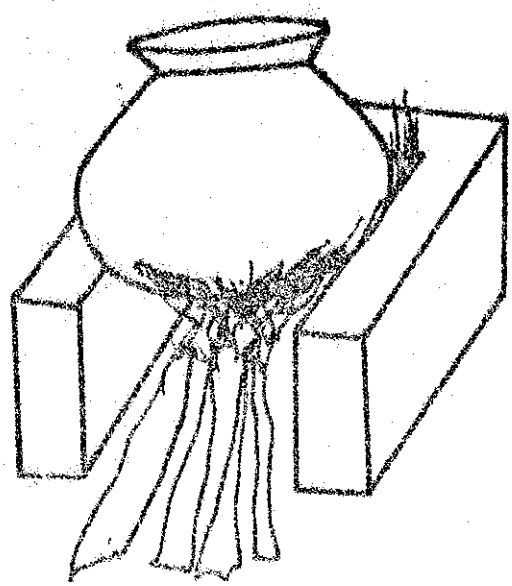


FIG 2

C

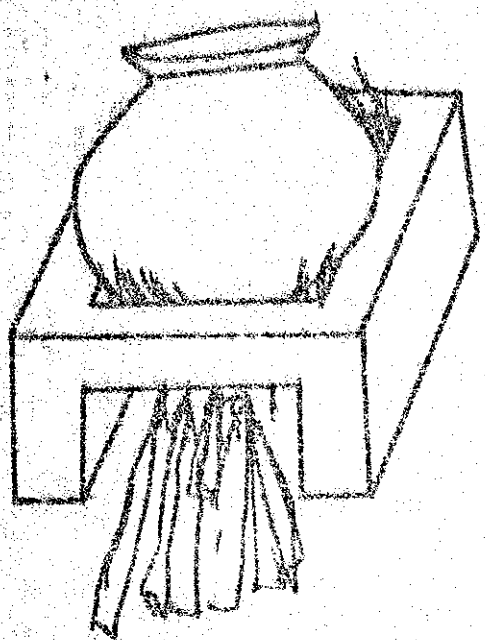


FIG 3

D

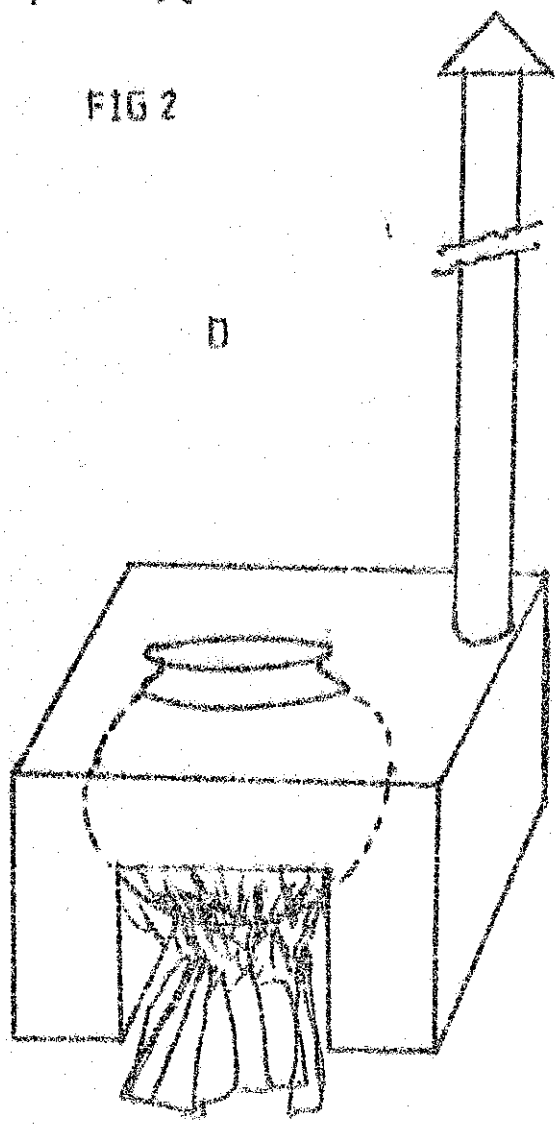


FIG 4

TABLE - 1

Some data[+] on the existing bath room stove

| Type | % occurance in a typical village Unchagi; cut of | % heat utilization | Special features |
|---|---|---|---|
| A | 25 % | 10 - 12 % | no grate, no chimney |
| B | 30 % | 12 - 15 % | no grate, no chimney |
| C | 40 % | 14 - 16 % | no grate, no chimney |
| D | 5 % | 16 - 22 % | no grate, chimney of 3m height |

[+] Data presented here are average of 5 stoves of each type.

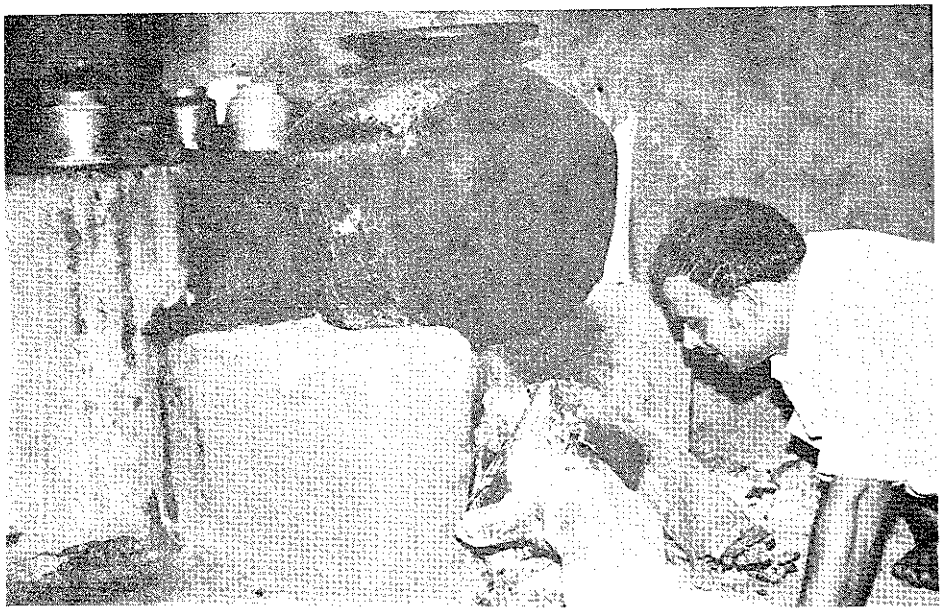


FIG 5

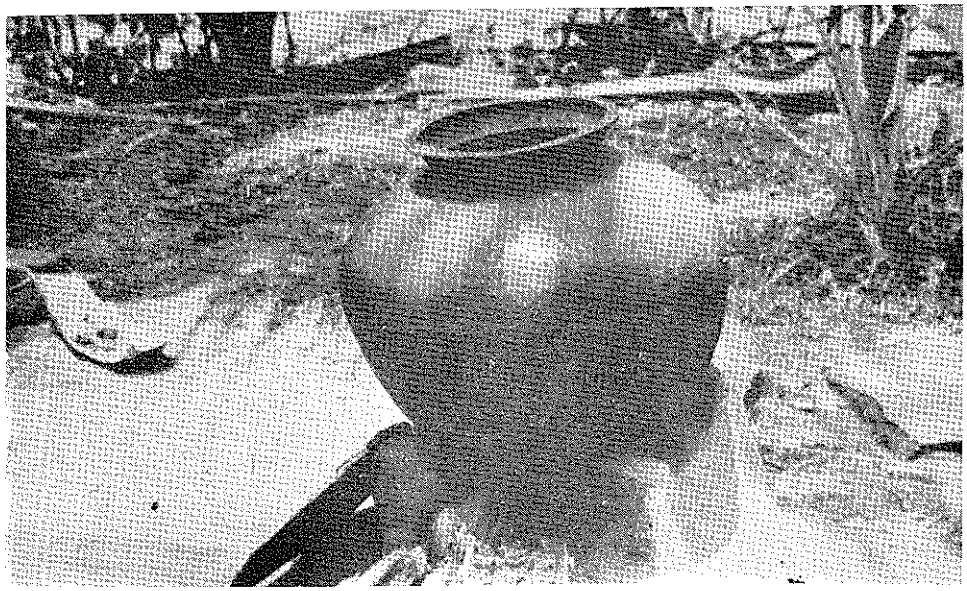


FIG 6

## 3.2. New bath room stove : design considerations

In the new stove, fuel is burnt over a cast iron grate and the flue gas is left outside through a chimney. Assuming that atleast 35 % efficiency should be achieved, quantity of wood to be burnt for heating 50 litres of water from 25°C to 50°C was estimated. Taking the calorific value of 3800 K cals/kg wood required comes to 0.94 kg. In the 3 pot wood burning stove[3], with in a grate area of 15cmx15cm, 2 to 3 kg could be burnt in one hour. Therefore, 15cmx15cm grate is considered sufficient for bath room stove so that about a kg can be burnt in 25 to 30 minutes. Standard 10cmx25cm chimney is easily available and similar ones are now used in the ASTRA OLE. Therefore, chimney of 10cmx3m is chosen.

## 3.3. Fabrication of the new stove

With the constraints laid down and the design parameters arrived at, the stove was constructed out of laterite stone. Bricks can also be used for construction. The first step in the construction is to measure the outer diameter of the vessel. Then the positions where chimney is to be fixed, fuel inlet and the ash removing space has to be decided.

It would be ideal if the fuel feed hole is in the opposite direction with reference to the chimney. As per convenience of space available in the bath room, position of the vessel, fuel feed hole, primary air inlet and chimney be marked as shown in Fig.7. It should be noted that the grate is kept towards the fuel box from the centre of the vessel. Size of the fuel box can be adjusted to the length of the wood normally used. A few steps of stove construction are shown in fig.8. Keeping a brick or a stone support in the bottom, a vessel should be placed such that distance between the vessel and the grate is 12 to 14 cm. The vessel can be completely dipped inside the stove leaving only the neck. To that extent, height of the stove wall should be raised. The fuel feed hole can be about 20 cm x 20 cm so that even bigger size wood can be pushed over the grate. Arrangement should be made to close the air inlet either though a door or keeping a brick so that only about 1 cm x 6 cm air inlet hole is provided. While removing the ash, the door can be opened. Cross-sectional view of the stove is shown in fig.9. After constructing the square well out of stone, inside of the stove should be shaped by packing the empty space with rice husk mud mixture so that only about 3 to 4 cm gap is provided between the inside wall of the stove and the vessel. Finally tile or asbestos sheet pieces can be

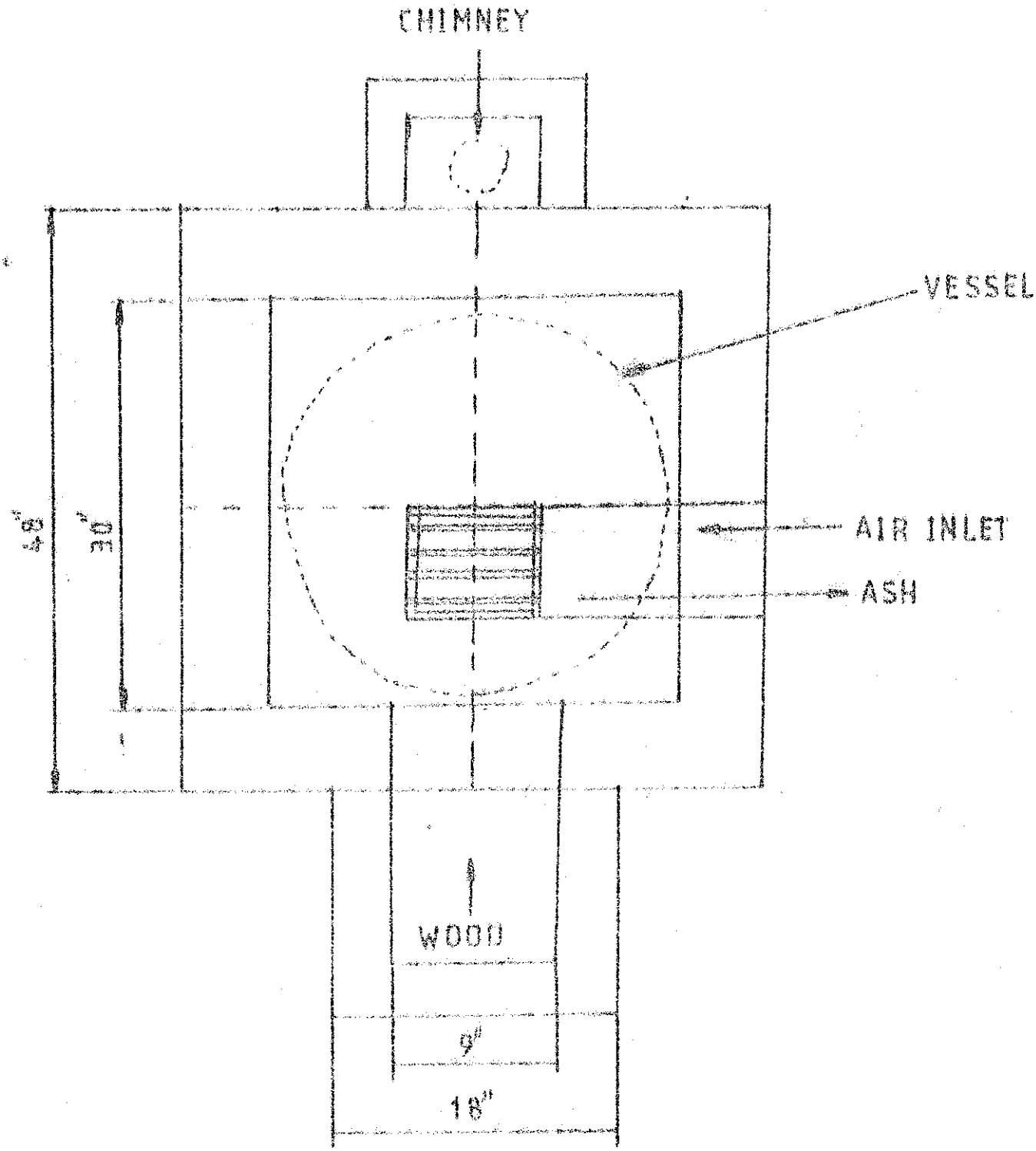
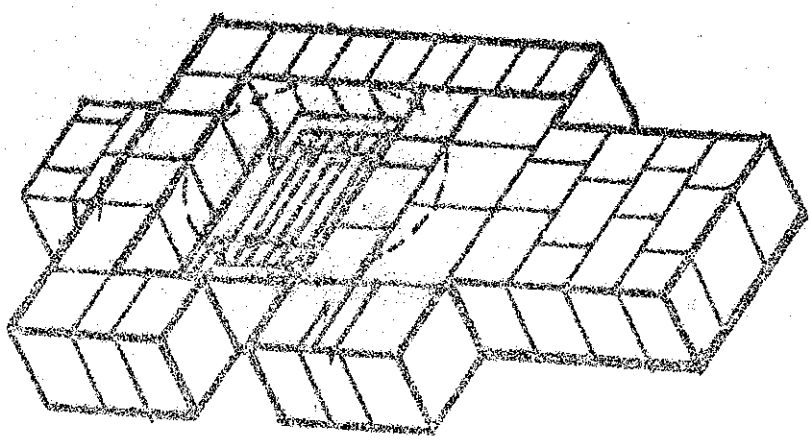
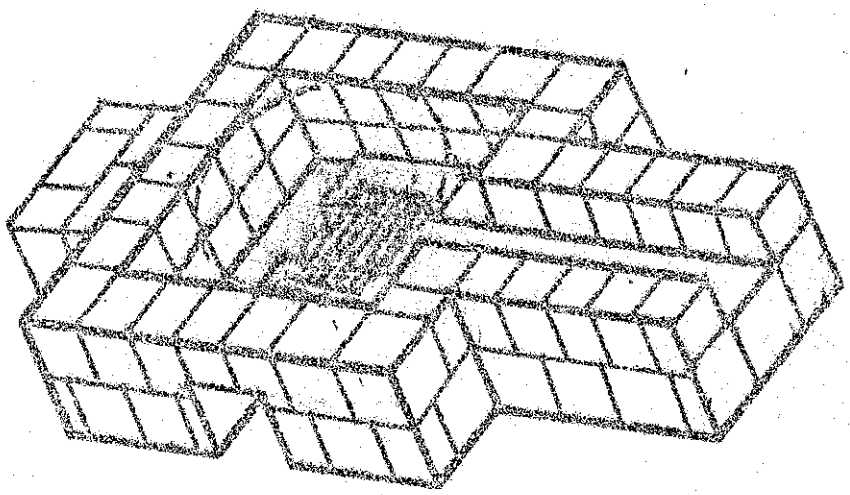


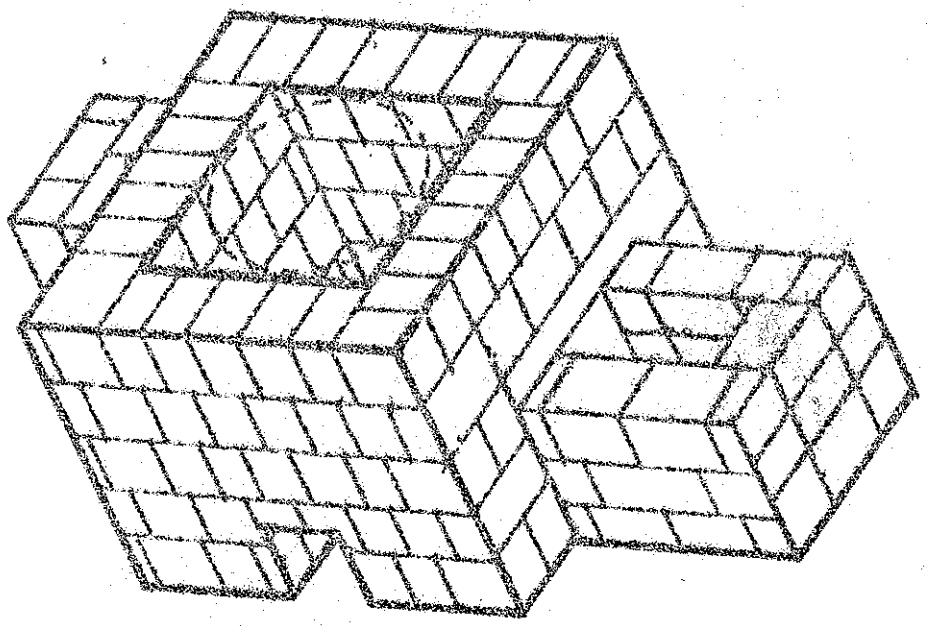

Fig 7



(A)



(B)



(C)

FIG 8

used to cover the top part after keeping the vessel in place sealing the top of the stove with rice husk mud mixture. Only about 5 cm x 5 cm area from the top part be left for passage of flue gas to the chimney. These details are shown in Fig.9.

The stove can be fired after about 8 to 10 days of construction. The results of experiments carried out on the stove performance are given in Table 2. The stove parameters were varied to arrive at highest efficiency.

From Table 2, we can see that 40% efficiency is achieved when (a) distance between the grate and the bottom of the vessel is 12 cm; (b) the fuel box is kept closed; only while tending once in 8 min, fuel box lid is opened; (c) 2 cm x 5 cm gap is the air inlet hole below the grate. This ensures no back firing of fuel in the fuel box. Temperatures of the combination zone (5 cm above grate) as well as flue gas at the bottom of the chimney were measured using a Chromel-Alumel thermocouple. The temperatures recorded respectively were 890°C and 130°C. This is compared with that of similar stove without grate (fig.4 type) wherein 750°C was the temperature in the combustion zone and 225°C was the flue gas temperature. In fig.10, plot of increase in water tempera ure , temperature at the combustion zone and that of the flue

TABLE - 2

Variation of PHU with varying the critical parameters; air gap below the grate (1 cm x 5 cm)

| No. | Distance between pot bottom and grate | Annualar space between vessel and wall of the stove | efficiency PHU |
|---|---|---|---|
| 1 | 18 cm | 5 cm | 25 % |
| 2 | 15 cm | 5 cm | 32 % |
| 3 | 12 cm | 5 cm | 36 % |
| 4 | 12 cm | 4 cm | 32 % |
| 5 | 12 cm | 3 cm | 40 % |

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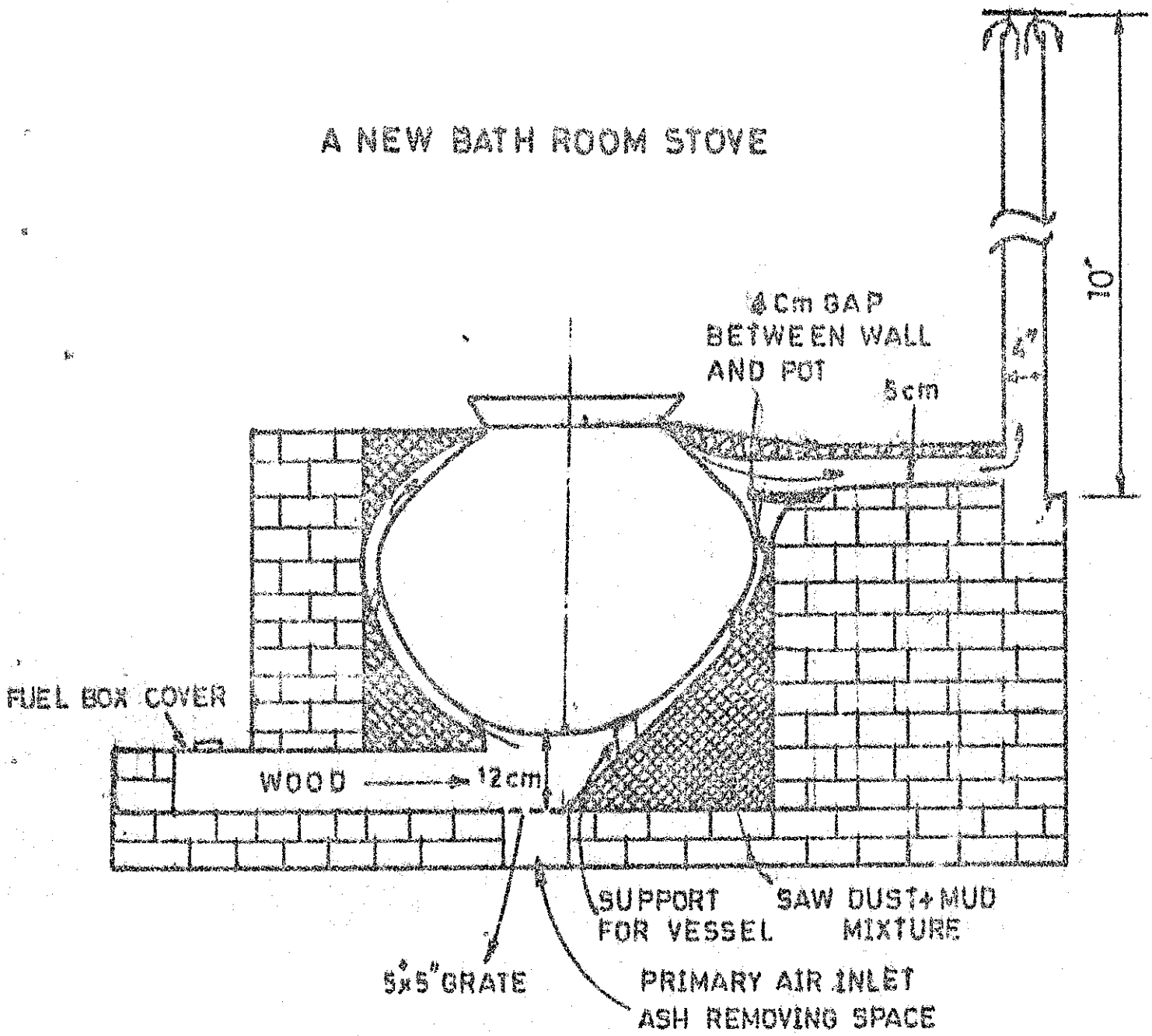


FUEL EFFECIENCY = 40%
COMPARED TO 15% OF TRADITIONAL ONES
SAVING IN FUEL 60%

Fig 9

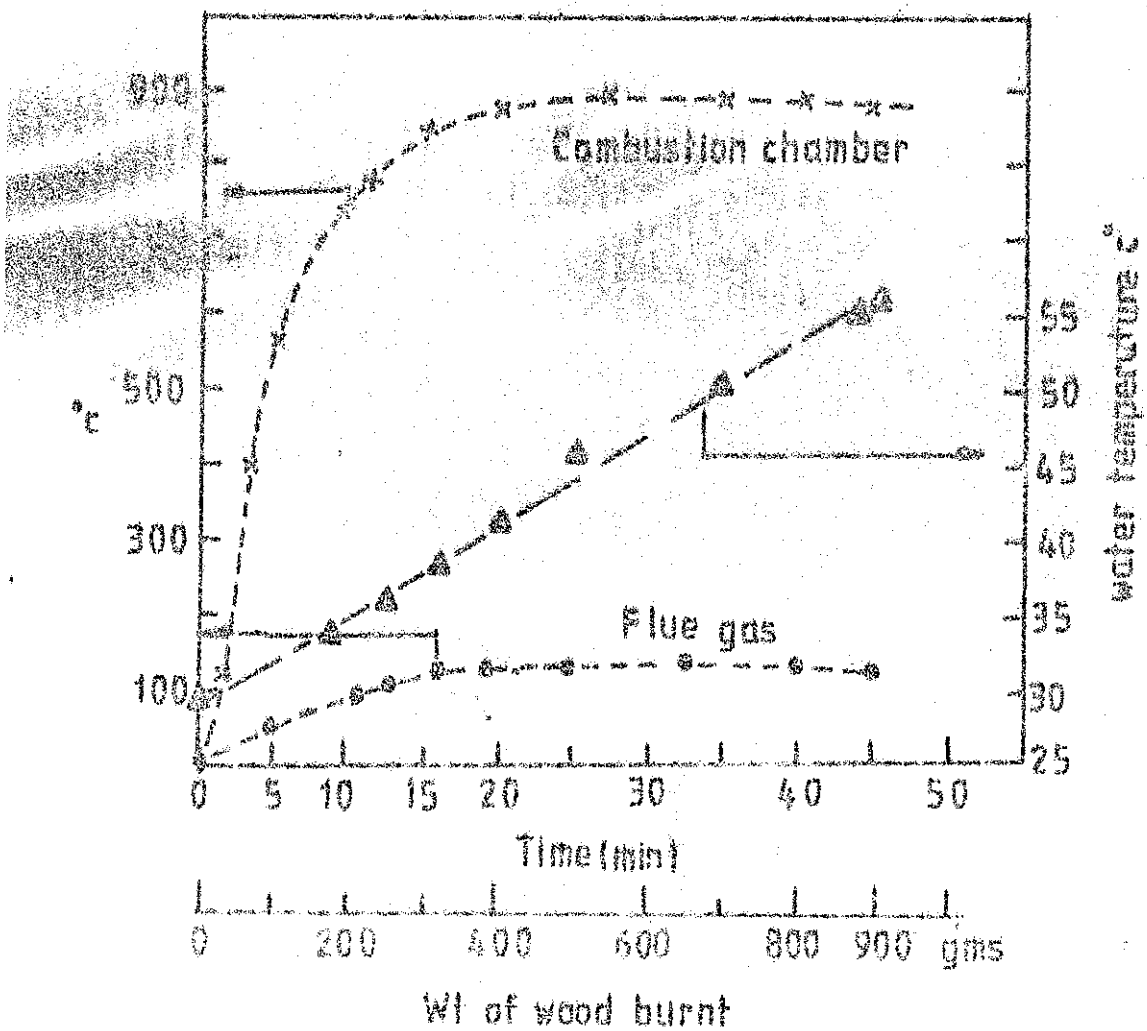
800
500
300
100
°c
Combustion chamber
Flue gas
55
50
45
40
35
30
25
Water temperature °c
0 5 10 15 20 30 40 50
Time (min)
0 200 400 600 800 900 gms
Wt of wood burnt

Fig.10

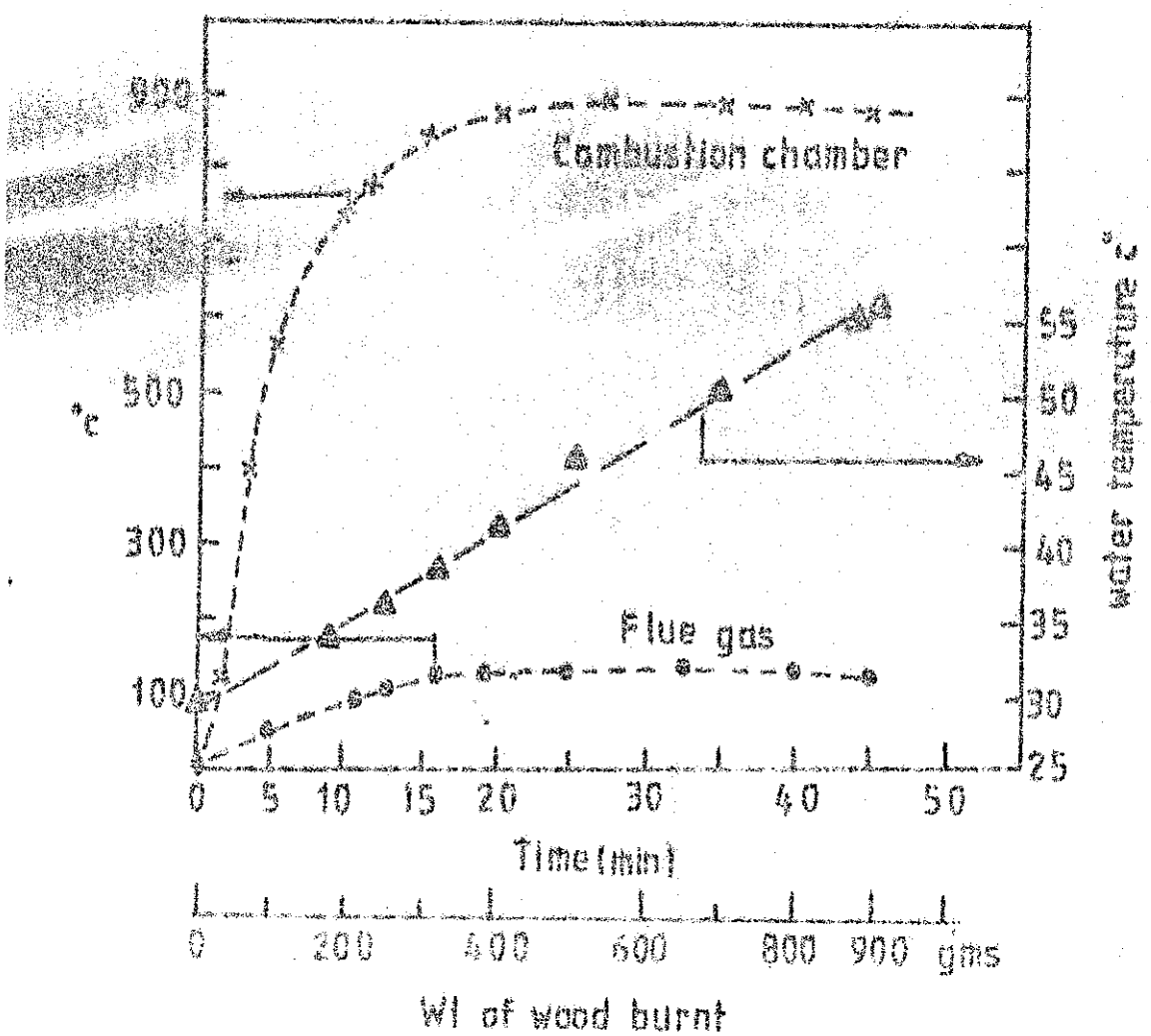
Combustion chamber
Flue gas
°c
water temperature °c
Time (min)
Wt of wood burnt
gms

Fig.10

gas against time and amount of fuel burnt is given.

## 3.4. Comparison of the traditional stove with the new stove

In order to evaluate the new stove about its utility, a comparison between the old and new is in order. This is given in the table 3.

TABLE - 3

| Details | Old stoves | New stoves |
|---|---|---|
| a. Materials for construction | Stone/brick,mud chimney(if there is one) | Stone/brick,mud,rice husk chimney, 20cmx20cm cast iron grate, wood box cover |
| b. Fuel | Wood,twigs,dry leaves,dung cakes | Wood,twigs, dry leaves dung cakes,coconut husk, arecanut husk |
| c. Comfort | Types A,B,C are smokey only type D emits less smoke | Totally smokeless; easy to light, easy to maintain(by fanning through ash removing space) |
| d. Cost | Cost is due to bricks/stone chimney(if there is one) and labour | Same as traditional ones except the grate, chimney if it is not there, fuel box cover |
| e. PHU | 10 - 22 % | 40 % over 60 % saving of fuel compared to most of the traditional ones (A,B,C) |
| f. Time for heating | about 50 min to make 50 lit. of water ready for bath | Only 20 min. to make 50 lit of water ready for bath. |

By achieving 40 % heat utilization, 60 % or more of fuel can be saved compared to most of the stoves prevalent in Uttara Kannada villages. It is shown that just 700 gms of wood is sufficient to heat 50 lits of water from 25°C to 47°C in 20 min. sufficient for 3 people atleast. These results meet the design constraints. Since the fire is totally enclosed, there is practically no fire hazard. This is very important because the bath room in villages are generally low roofed. Bath rooms catching fire and spreading to the main house is very common in these villages.

## 4. Concluding remarks

The above stove is put up at Unchagi, (Sri.S.R.Hegde's house) a village in Kumta taluk in Uttara Kannada district and also in A-43, CIL colony, Sanjay Nagar, Bangalore 24. Any kind of fuel except rice husk or saw dust can be burnt efficiently. Fuel efficiency is 40 % and saving in fuel is atleast about 60 % compared to conventional bath room stoves.

## Acknowledgements

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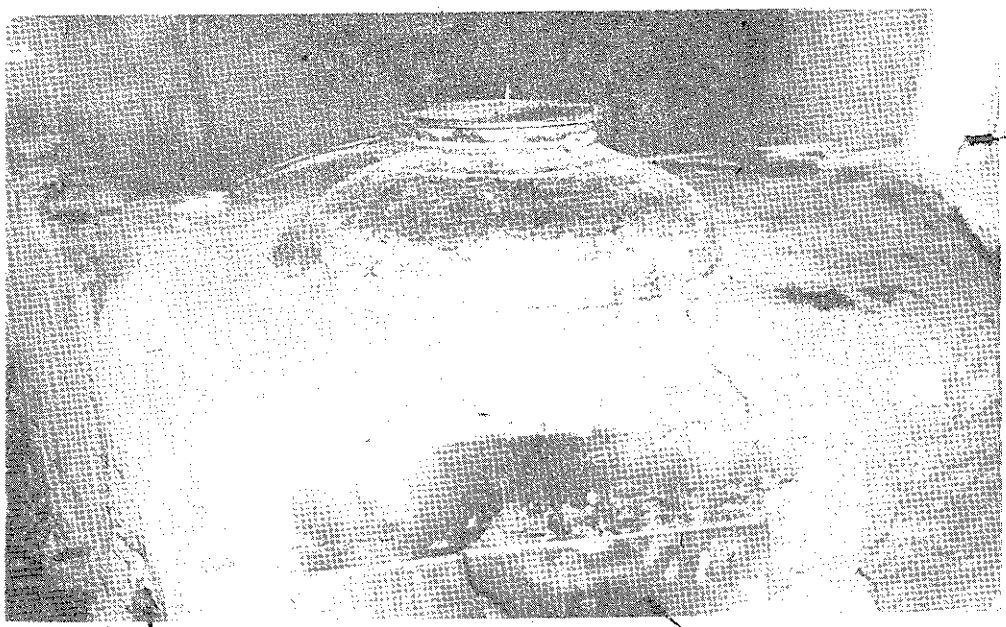


FIG 11