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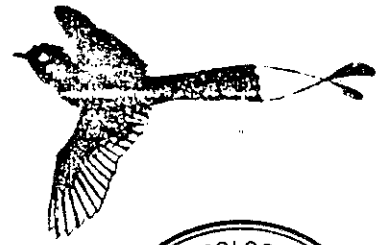

A STEP TOWARDS CONSERVATION OF FUELWOOD "ASTRA OLE"- DIFFUSION AND PERFORMANCE IN UTTARA KANNADA

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Abstract

A systematic study of fuel consumption pattern, efficiencies of conventional wood burning stoves, fuel saving in ASTRA OLE has been carried out for the villages of Uttara Kannada. A model for realizable fuel saving in ASTRA OLE is provided. As against an expected 57 percent fuel saving, 31 percent fuel saving is achieved. The stove has been widely accepted in Uttara Kannada.

2 Materials and Methods

Uttara Kannada is one of the Western Ghat districts of Karnataka. Average annual rainfall in this region is 3000 mm mostly received during the months of May-October. The entire district is hilly area. The villages are situated in the valley. The total area under the forest cover is about 30 percent. The district has 11 towns and 1223 villages with a population of 13,72,930. The population in the towns is 2,72,300 and average population of a village is 428. For this study 3 villages were chosen viz., Unchani, Thairuthe and Heravalli which are typical of Uttar Kannada in terms of average population vegetation cover, food habits and agricultural practices.

Efficiency of wood burning stove

Caloritic value of commonly available sun dried timberwood in Uttara Kannada such as terminalia tomentosa(Matti) or xylia xylocarpa (Jambe), for 15 days, is about 3800 kcal/kg. When the same wood is oven dried for about 4 hours at 111 C, the caloritic value goes upto 4000 kcal/kg. In this study sun dried wood has been used. caloritic value of charcoal was taken to be 6000 kcal/kg.

Efficiency of wood burning stove is measured by boiling water test.

$$\% \text{ efficiency} = \frac{(\text{wt of water} \times T) + (\text{wt of water evaporated} \times \text{latent heat})}{(\text{wt of wood burnt} \times \text{calorific value of wood}) + (\text{wt of charcoal} \times \text{calorific value of charcoal})}$$

where T is the rise in temperature and the weights are expressed in kg. The second and simpler method was to measure Specific Fuel Consumption (SFC) defined as follows:

$$SFC = \frac{\text{Weight of wood burnt (in gms)}}{\text{Weight of cooked food (in kgs)}}$$

In this method, total quatity of cooked food was weighed after the house wife cooked a meal burning a weighed quantity of wood and the value is expressed in gms/kg. Lower the SFC value higher is the efficiency of the stove. While in the first method, the reliability of which depends upon the quality of the cook and the measurement gives directly the relative figure of the stove, in method is easy for field trials of new stoves. Therefore, the SFC measurements have been carried out more extensively in this study.

3. Results

Fuel consumption Pattern

In order to assess the quantity and type of fuel used, a survey of fuel consumption pattern has been conducted in 100 percent of the houses in one of the villages, Unchagi. The actual quantity of fuel needed for one day domestic use was weighed before hand and the fuel requirement was estimated from the experimental method. Number of houses was 63 with 383 population in Unchagi. The results of the survey on the nature of the fuel, the purpose for which it is used and the source from where it is available are given in table 1 and

Table 1 : Fuel [illegible] for one day domestic use in Unchagi.

Fuel type	Cooking kg/day	Bath water heating kg/day	Total kg/day	Source
Cut wood (matti, jumbe etc.)	223	49	272	[illegible] forest, bettaland (1-3 km dist.)
Shrubs and twigs	207	151	358	Minor forest 3 km dist.
Coconut tree products	13	63	81	Plantation [illegible]
Areca tree products	[illegible]	[illegible]	20	"
Miscellaneous	-	10	10	Minor forest
Kerosene	-	-	-	

Table 2 : Types of stoves and fuel efficiencies of conventional wood burning stoves in the villages.

Village	No. of Houses	Type of stove	No. of occurrences	Efficiency	[illegible]
1	2	3	4	5	6
Unchagi	[illegible]3	A	[illegible]	11.[illegible]+[illegible]( )	[illegible]5 [illegible]
		B	[illegible]	16.20+4(15)	4[illegible] [illegible]
		C	2[illegible]	16.89+3(19)	350 gms/kg
383		D		18.0+3.5(9)	31[illegible] gms/kg
people		E	1	21.4 (1)	28[illegible] gms/kg
Bhairumbe (sirsi)	62	A	2		450 gms/kg
430		B	42		430 gms/kg
people		C	38		351 gms/kg
		D			
		E	nil		
Bhondle (sirsi)	153	A	-		
		B	49		432 gms/kg
		C	46		3[illegible] gms/kg
—		D			
		E	nil		

+ Number in bracket show the number of measurements

the fuel need for cooking and bath water heating are the main daily requirements in this village.

The fuel need for cooking is 1.22 kg/day/person and that for bath water heating is 0.81 kg/day/person. It is found that 85 percent people take hot water bath once a day and the rest once in 2-3 days. Thus, the total quantity of fuel required for cooking and for bath water heating is 270 tonnes/year. In addition, for parboiling rice (generally carried out after two rice harvesting seasons) about 30 tonnes of fuel mainly in the form of dry leaves and twings is needed. Thus about 300 tonnes of fuel that amounts to 0.82 tonnes per house annually is the demand on fuel from this village.

The rice husk is used as manure in the fields and is not used as fuel. Generally, in Uttara kannada, sugarcane juice is boiled to make liquid jaggery using wood. But in this village, due to the introduction of the baggasse fuelled two pan furnace, 40 tonnes of fuelwood is saved annually (4) since 1981.

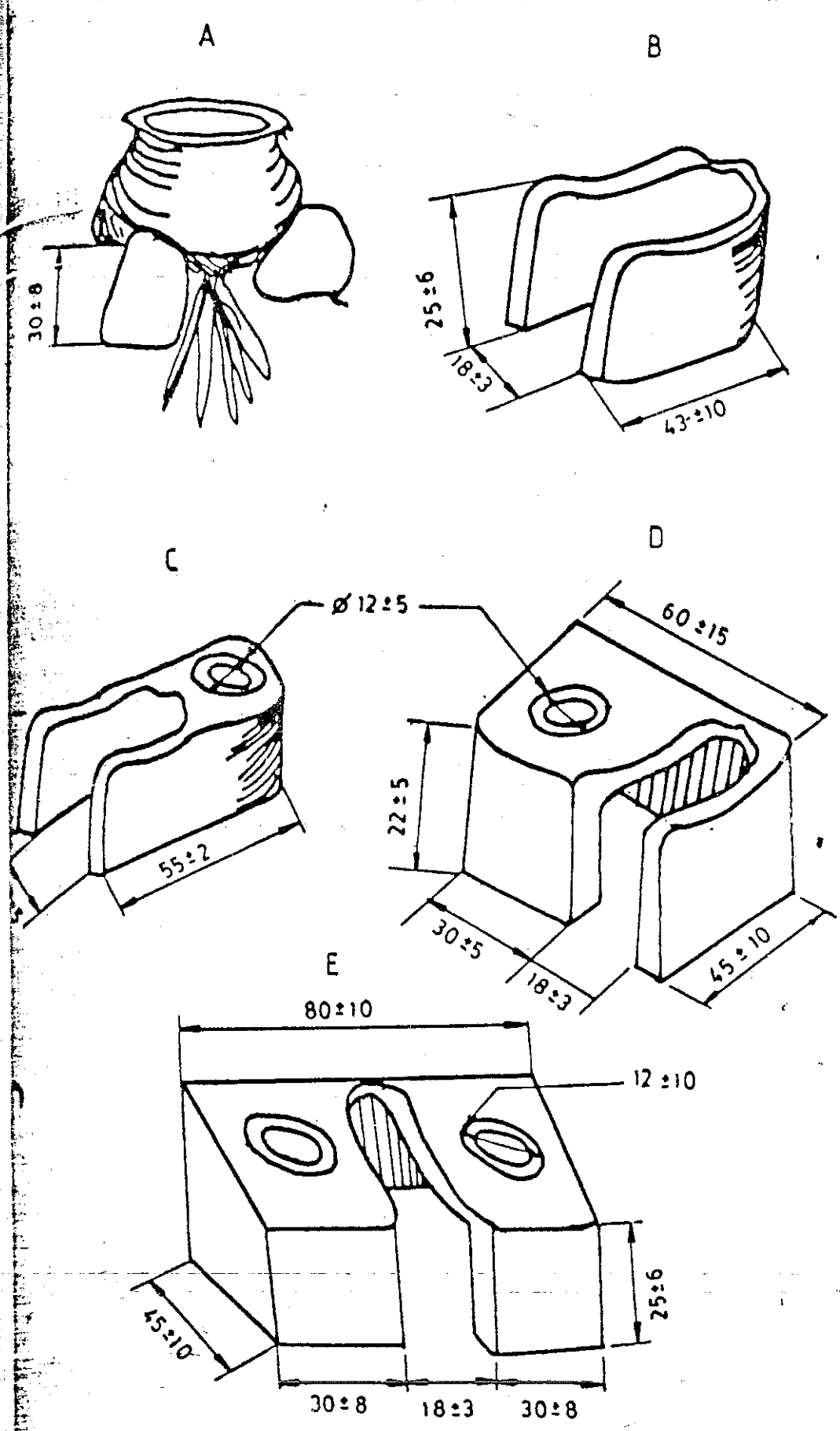
Out of 300 tonnes of fuel annually needed, 35 percent is for cooking, 15 percent for bath water heating and the rest for parboiling rice and many other uses. Clearly, the most important use of fuel is for cooking food. Fuel for cooking food and bath water heating together cover 90 percent of the fuel needed. Yet another point to be noted here is that about 35 percent of the fuel is in the form of cut-wood, 50 percent in form of shrubs and twigs, and about 15 percent of the fuel is met out of agricultural residues. Cowdung cake as a fuel is not being used now, since its value as manure is considered high. This is true only in villages while in towns dung cakes are used as fuel. Only one house has a biogas plant in Uncha i

and gas is used for cooking, which is thus a small quantity taken village as a whole. Kerosene is not used for cooking fuel but it is used for lighting.

A fuel consumption pattern study in other two villages of Uttara Kannada viz. Bairumbe and Bhavale shows that over 95 percent of the fuel is met from biomass only. Depending upon the status of the resoures of the minor forest, area under the plantations such as coconut and arecanut, variation in the percentages of the nature of the fuel in the different village of Uttara Kannada are observed. For example, in a village like Bhairumbe, more of cut-wood is used since minor forest is relatively well maintained, but in the villages like Nuroor, Hosakuli in the Kumta and Honnavar Taluks respectively, agricultural residue form about 30 percent of the total fuelwood needs.

Conventional wood burning stoves

A study on the types of the wood buring stoves, percentage occurence, and their efficiency was undertaken in three villages with 100 percent sampling. The types of the stove used for cooking can be classified into 5 categories as shown in fig.1. In the figure, various stove dimensions have also been given. The large variatin in sizes are due to the variation in the number of people in the houses. The stoves are made of stone and mud only. In table 2 the percentage occurence of different types of stove, their efficiency and the SEC values are given. A typical conventional stove is shown in fig.2. SEC measurement were caried out in over 40 houses chosen randomly in these three villages. The frequency distribution of SEC values is given in the fig.3. Average SEC was 405±123 gms/hr. In none of the houses in the three villages(282 houses), the wood burning stove had a chimney. The



NOTE: ALL DIMENSIONS IN CM

Fig. 1

Typical Conventional Stove

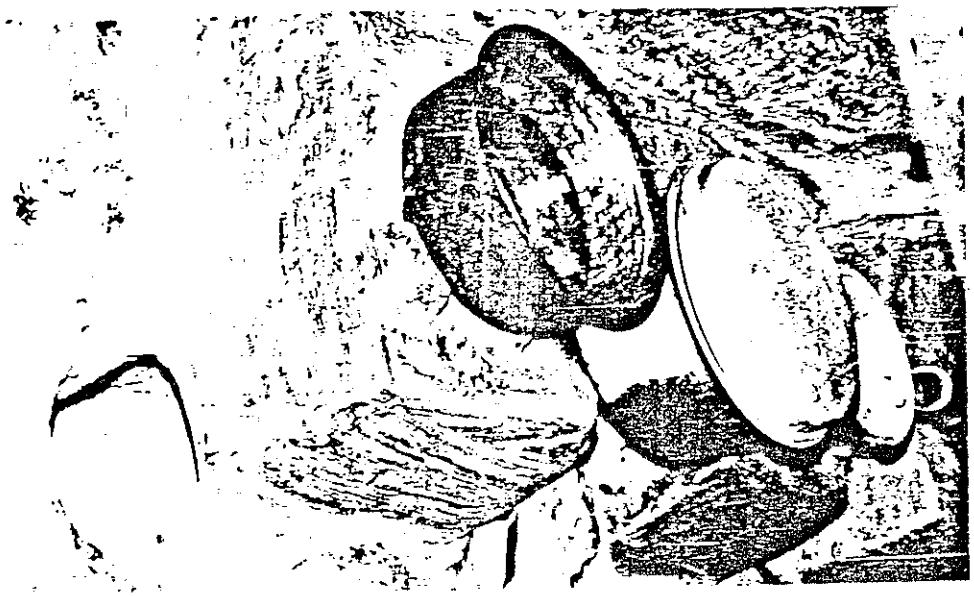


Fig 2

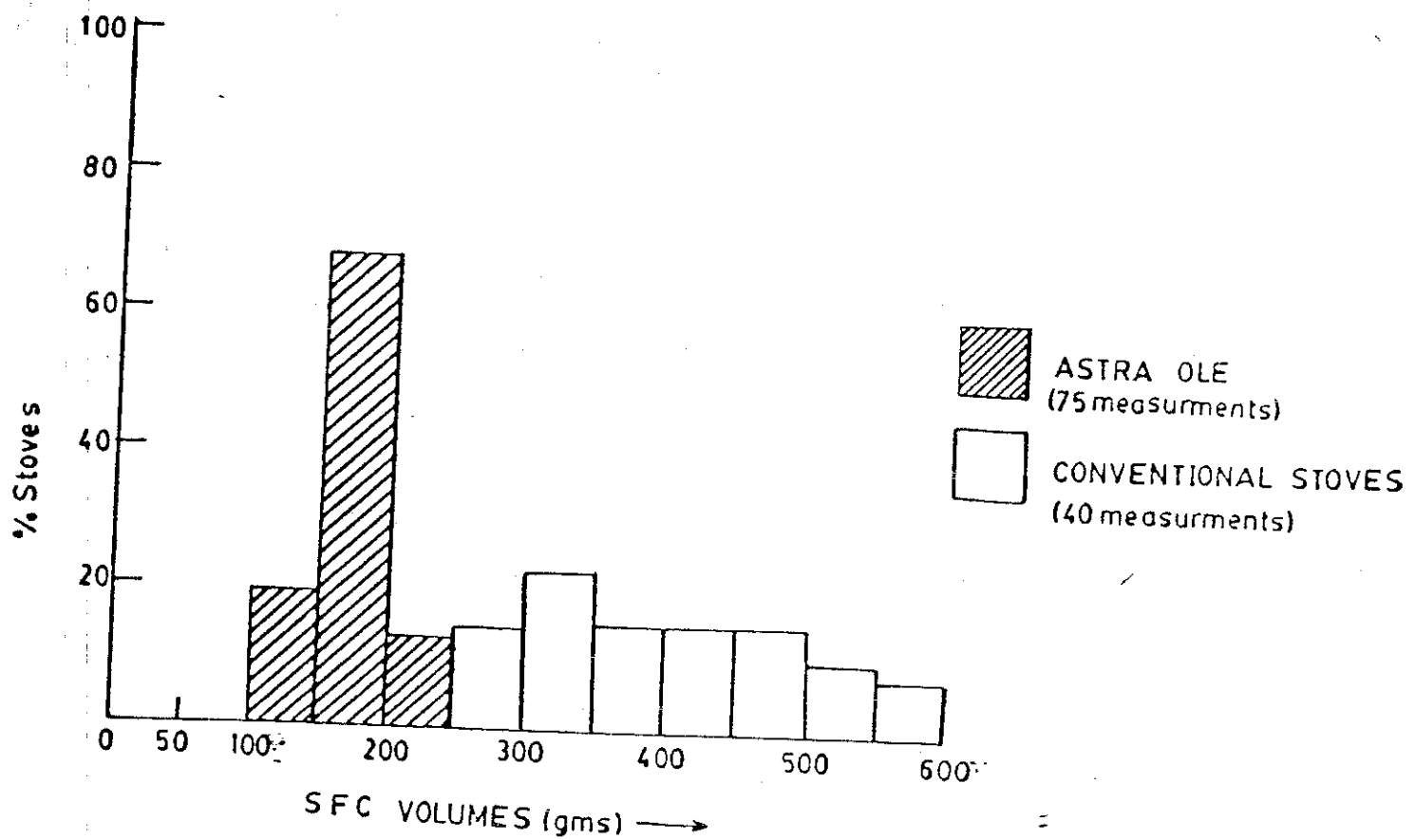

100
80
60
40
20
% Stoves
0
50
100
200
300
400
500
600
SFC VOLUMES (gms) ⟶
ASTRA OLE
(75 measurments)
CONVENTIONAL STOVES
(40 measurments)

Fig 3

stoves in general are smokey and therefore,lesser quality fuel such as husks and shrubs are not preferred to cook food. The latter efficient(with highest S.C values) three stone stoves (A type - i.e.1) is common among the labour community in Unachuqi. Perhaps this is due to the fact that they are easy to construct and do not need any skill. The single pot stove (B type) is present in 40 percent of the house holds. The fuel efficiecy is 16±4 percent. The two pan stove (C and D type) together occur in 58 percent the houses. The C type stove has an efficiency of 16.8±3 and the D type has 18(.0±3.5 . Three pan stove (E type), is very rarely found. The measurement in a single house having E type stove showed an efficiency of 2J percent. Even though the efficiency of this type is higher, people have not not constructed three pan stove. An enquiry into why the three pan stove are not common showed that (1) the construction needs extra skill due to the [illegible] and (2) the main central stove is not strong enough for keeping vessels of higher volume, (3) and flame gets diverted to the side two holes with the effect that cooking in the central stove is slowed down.

The stoves are constructed out of mud and stone. They are of high mass type (2). they are built at the site and not portable. Periodical cleaning is carried out using cowdung generally on friday morning. Thus the stoves are costless. Stoves are important part of the houses and treated with great reverence and traditional respect. While cooking, women generally have to face east and fuel is fed in right hand. they are maintained by the housewives and remade once in 2 years.

Diffusion of fuelwood efficient three pan ASTRA OLE

Based on the Community jaggery unit (4) a three pan wood burning domestic cooking stove was designed in ASTRA Centre, II (5). The main characteristics of the stove are:

a) The fuel is burnt on a cast iron grate and the controlled amount of air required for burning is allowed through a gap below the grate with a shutter.

b) Distances between the bottom of the pans and the top surface of the stove are adjusted for maximum heat transfer to the vessel and these distances are 13 cm, 4 cm and 2.5 cm below the 1st, 2nd and 3rd pan respectively.

c) In the design, the standard 3 round bottom aluminium vessels of the same size are used and the vessels are dipped into the holes to the extent of 3/4 of the total height to achieve maximum heat transfer.

d) The flue gas generated is allowed to pass through the bottom of the 2nd and 3rd pans and finally let through a 2-3 meter long and 10 cm diameter chimney.

f) A secondary air-hole is provided for burning the volatiles above the grate.

g) There is no gap between the pots and the stove.

h) To reduce the heat transfer to the walls of the stove, a heat insulation of 3 cms thickness made of rice-husk and mud in 1:1 proportion is provided. These details can be found in fig.4.

FOR ROUND VESSEL

(a)

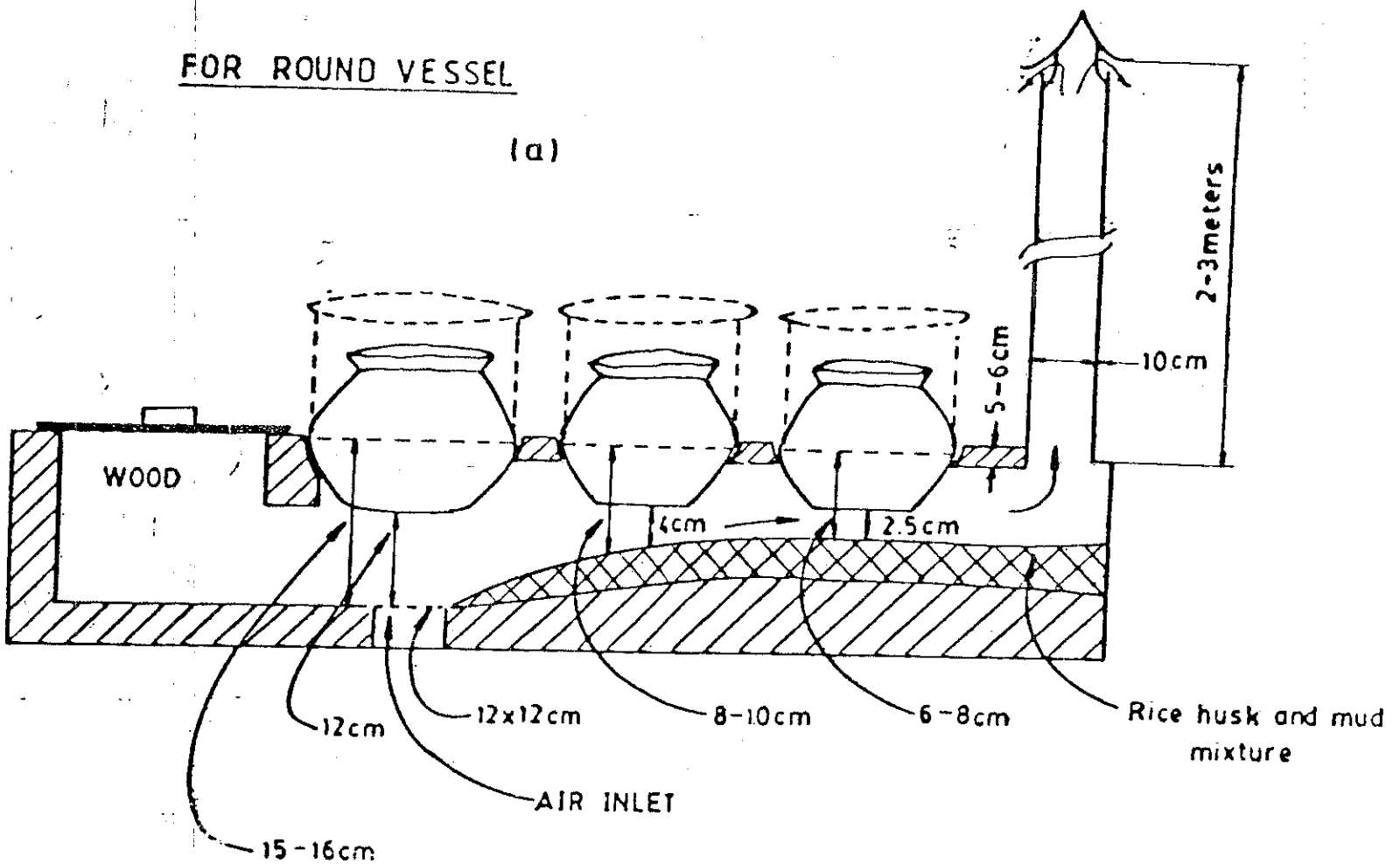


Fig. 8 4

The highest efficiency of this stove is 20 - 15 and 10 percent in 1st, 2nd and 3rd holes respectively and with a total efficiency of 45 percent; SFC value is 70 gms/kg. In all the 3 pans, water boils and thus, can be used for cooking.

For the first time, this stove was demonstrated in Unchagi. The stove was constracted out of locally available laterite stone and tile pieces. Local knowhow of curing the stove was adopted. The first stove constructed was called 'HOSA-CLE' (New stove). After its success, it was called 'ASTRA CLE'(ASTRA for Application of Science and Technology for Rural Areas - a centre at IISc and CFT for stove).

During the construction, there were a few difficulties in adopting the original ASTRA CLE design because of flat bottom vessels for cooking. However the bottom distances were adhered to as closely as possible by providing burns below 2nd and 3rd pan. The stove was tested for its efficiency which was about 32 percent and the SFC value was 162 gms/kg. From this it was clear that the ASTRA stove design has to be modified for cooking in the flat bottom vessels and a laboratory study was undertaken toward this. The results of this investigation are summarised in table 3.

When flat vessels are kept on a stove designed for round bottom vessels, efficiency was only 2% percent. The highest efficiency with flat bottom vessels for a family size of 6-8 people achieved in the laboratory was 41 percent. This is 4 percent lower than the ASTRA CLE for round vessels. This is essentially due to lower heat transfer area in the case of flat bottom vessels. The SFC values of the stove with flat bottom vessels was 110 gms/kg. The final design of this stove is

TABLE 3

VARIATION OF THE THERMAL EFFICIENCY OF ASTRA COOKING STOVE

WITH CHANGES IN DISTANCES

Sl. No.	Experiment	Distance below the pans			% Thermal efficiency in			Total
		1	2	3	1	2	3	
1.	Round bottom vessels of Al	13.0 cm	4.5 cm	2.8 cm	20.1	15.0	10.1	45.2
2.	Shifting of 1st vessel to 3rd after 1st is boiled	13.0 cm	4.5 cm	2.5 cm	12.3	12.1	14.0	38.4
3.	Al.flat vessels on the same stove as in expt.1 above	16.5 cm	9.5 cm	7.5 cm	14.0	5.3	3.4	22.7
4.	One round and two Al flat vessels	2.8 cm (Round)	4.5 cm	4.0 cm	17.3	9.7	6.9	33.9
5.	All flat Al.Vessels with optimum distances	11.0 cm	4.0 cm	2.5 cm	20.2	13.8	8.2	42.2
					1.0:	0.68:	0.4	2.08

15

shown in fig 5. It should be noted that even round bottom vessels of suitable size are kept on the flat bottom stove, the distances below the pots decrease by about 1-2 cms and hence there were no serious problem in its usage. Also it is ideally suited for keeping frying pans and such vessels and hence the stove could be used for cooking a variety of dishes in different type of vessels.

A simple method to construct this stove has been devised with locally available materials so that the precise stove parameters could conform to the original design. The steps to construct the stove is very briefly given in fig.6. A detail account of its construction can be found in ASTRA OLE construction manual (6). A typical ASTRA-OLE in Uttar kannada village is given in fig.7.

Field performance of ASTRA OLE

Several minor modifications were made during the diffusion of this stove in Uttara kannada villages. They were

a) Shutter for the air inlet provided in the original design was not essential and hence was discarded.

b) The stove is constructed out of mud. A small gap of the order of 2-3 mm between the stove seat and the vessel could not be avoided. Therefore the secondary air inlet was of no extra use and hence it was not provided.

c) Since the stove has to be adjusted for the vessels already available with the household, the distances are adjusted to suit the needs of both and flat vessels i.e the distances now are 11 cm, 4 cm and 2.5 cm below the 1st,2nd and 3rd vessels respectively.

d) The air of the third hole was always kept small at the request of the housewife since use for the third hole was not felt by them.

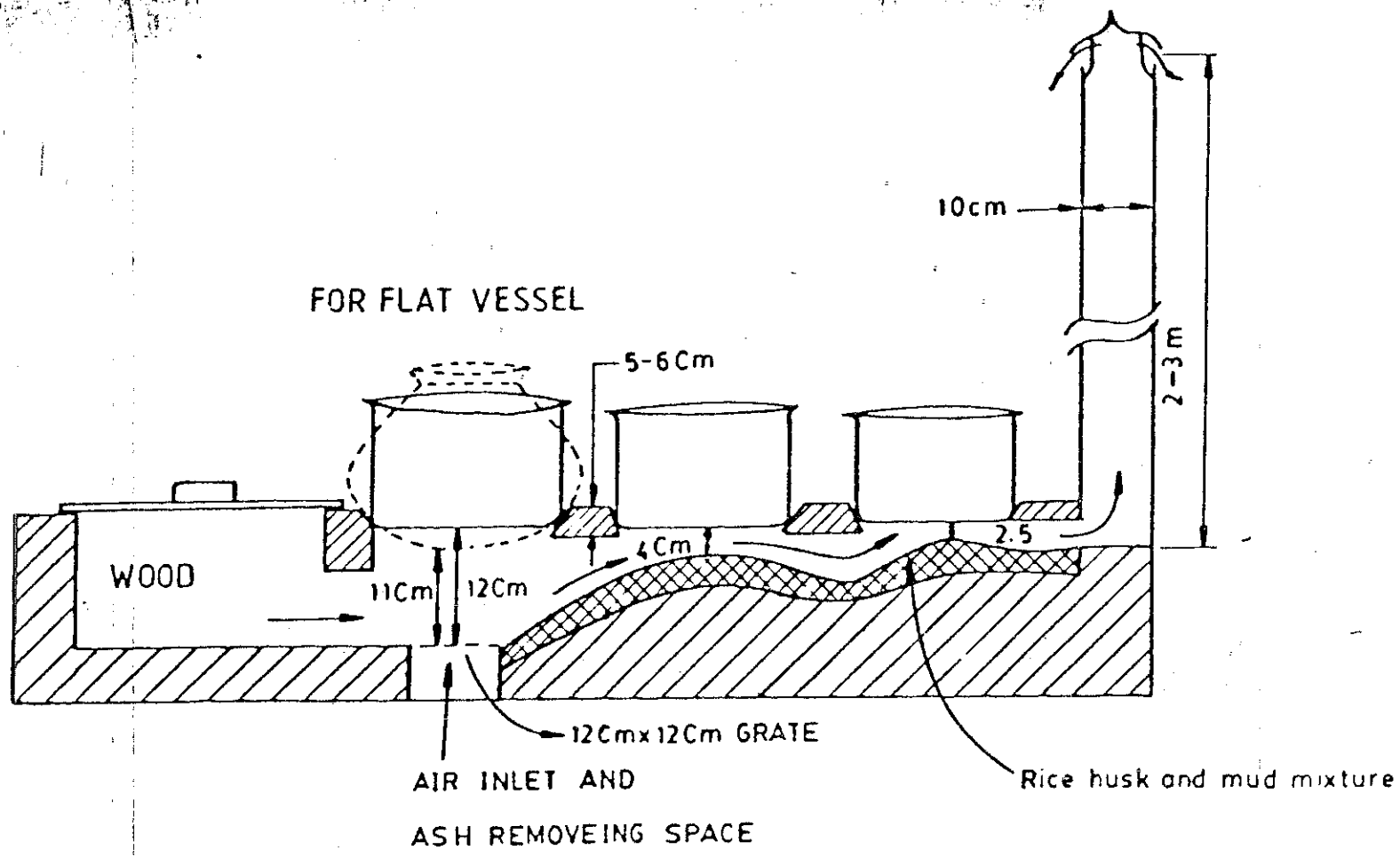
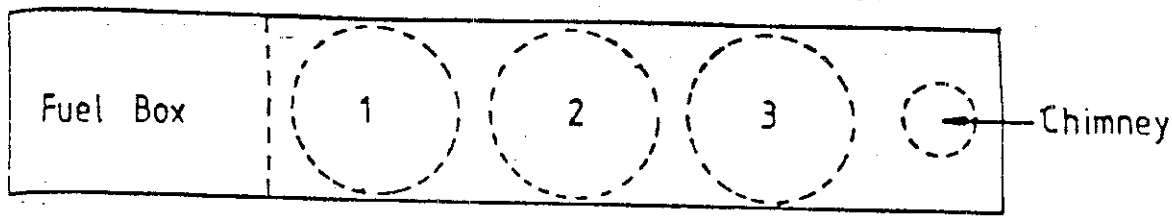
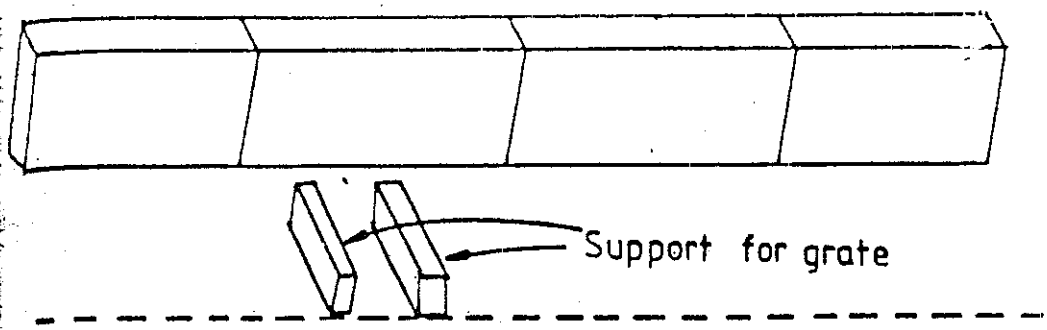

FOR FLAT VESSEL
10cm
2-3m
5-6Cm
WOOD
11Cm
12Cm
4Cm
2.5
12Cmx12Cm GRATE
AIR INLET AND
ASH REMOVEING SPACE
Rice husk and mud mixture

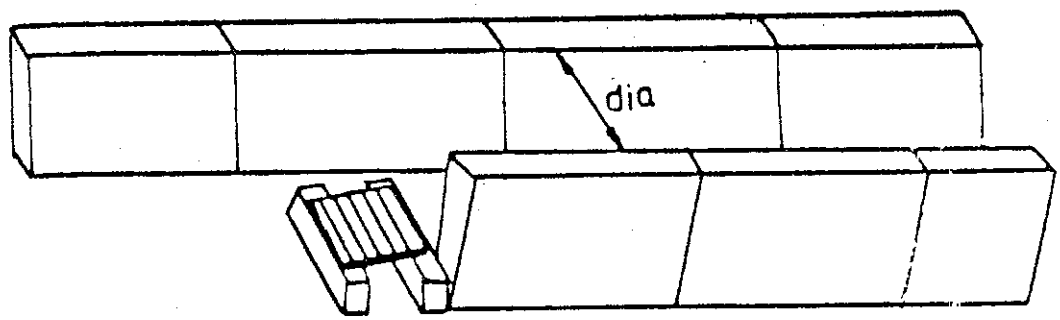
Fig. 5



(a)

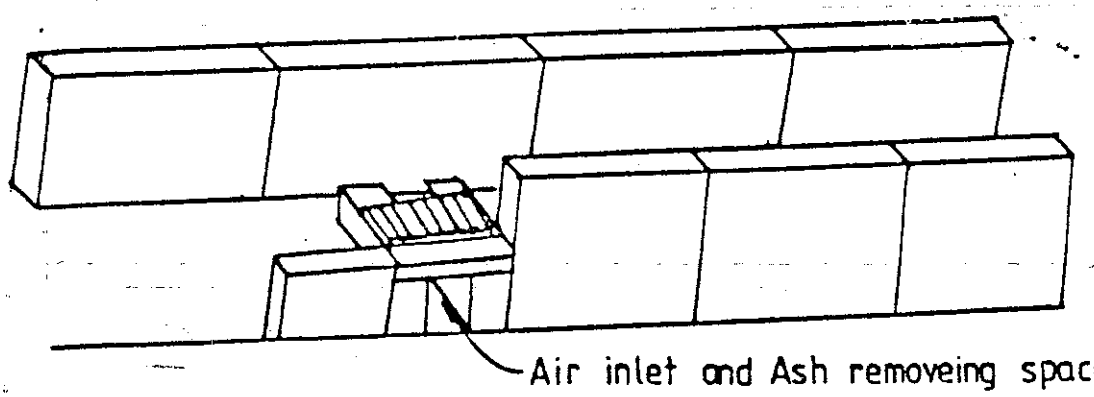


(b)



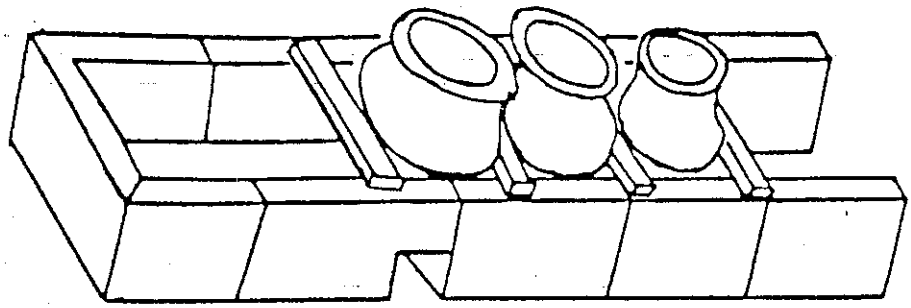
15cm x 15cm Cast iron grate

(c)

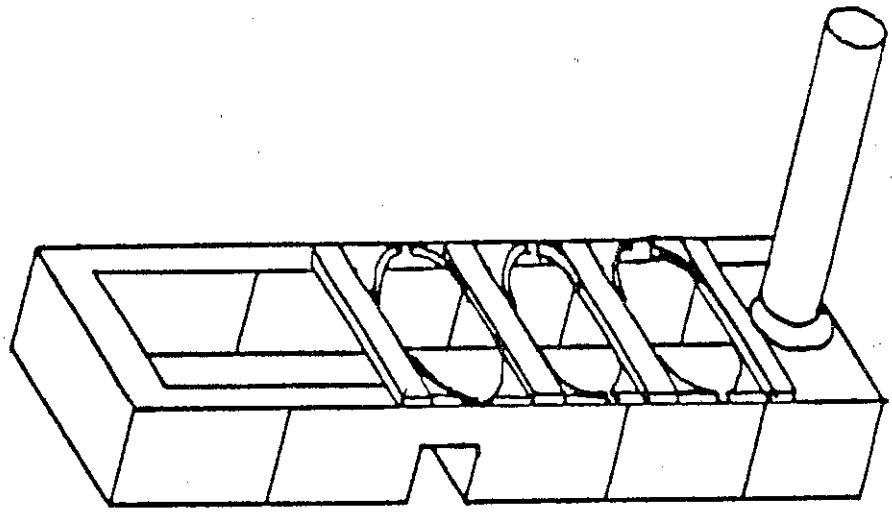


(d)

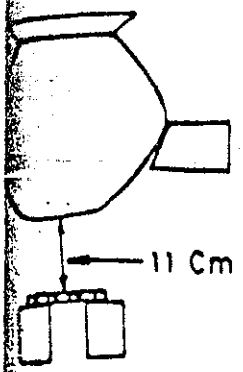
Fig. 5

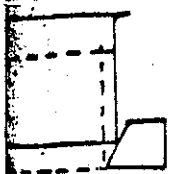


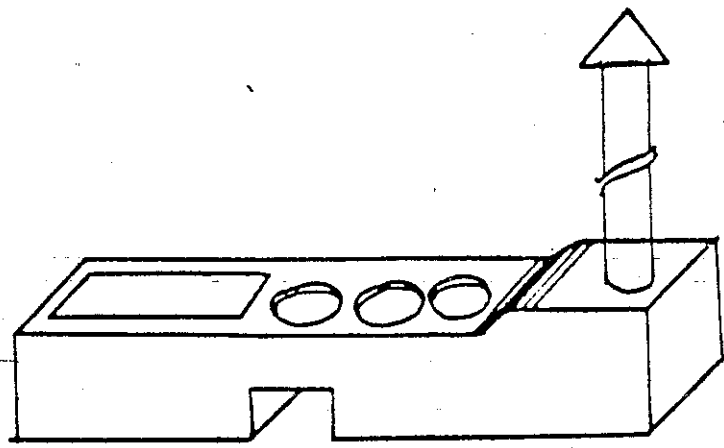
(e)



(f)







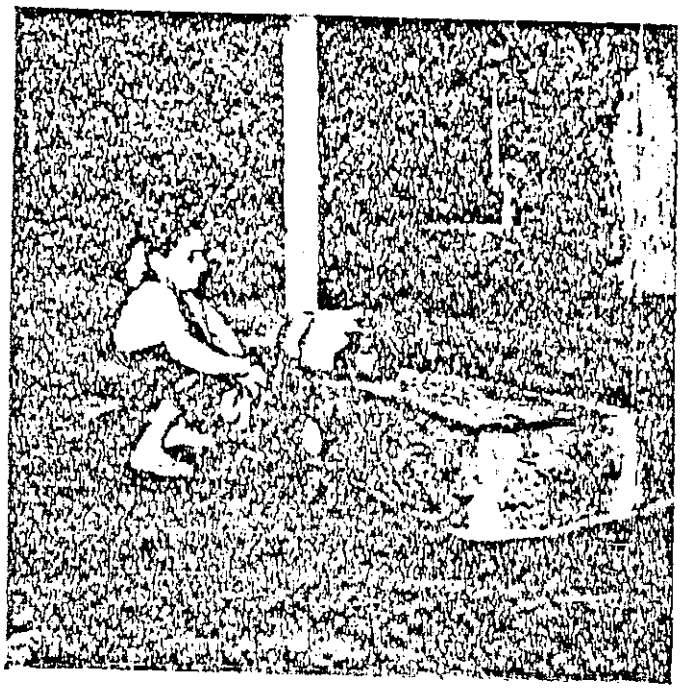
(g) Fig 6.

Over 5000 stoves in Uttara Kannada are now in use. In the 3 villages under study, 85 percent of houses have adopted ASTRA OLE.

The efficiency of these stoves could not be readily measured since the standard dried wood was difficult to carry from house to house. Also, housewives were not cooperative to measure efficiency by water boiling test because they felt that wood is unnecessarily wasted. Since SFC values are easy to measure during the process of their cooking, only SFC measurements were carried out to evaluate the fuel saving in ASTRA OLE. Frequency ditribution of SFC values is shown in fig.3.

The mean SFC value of 1/2±2[illegible] gms/kg (75 measurements) was obtained for cooking lunch hour food using the ASTRA OLE. Measurements were for a standard meal consisting of rice, vegetable curry and cooked vegetables. A comparision of SFC values is given in fig.3 and their distribution between ASTRA OLE and conventional stoves. Although the SFC value of 1/2 gms/kg obtained in the field condition is higher than the laboratory value of 110 gms/kg, it is 57 percent lower than the mean SFC value of the conventional stove. Therefore taking results of one time cooking in all the three vessels simultaneously, a saving of 57 percent of the fuelwood is achived in ASTRA OLE. In addition, the stove is smokeless, any type of fuel(except rice husk) can be burnt in this stove. Time required for cooking was reduced due to the fact that three dishes could be cooked simultaneously.

Fifty seven percent saving in fuel can be considered 'very good' when the SFC values are compared between the conventional and the ASTRA OLE, taking one time cooking measurements. It was of interest to see it the average saving could be as high as 57 percent. Therefore, a study of fuel needed for cooking food for a period of one week in a



ASTRA OLE AT UNCHAGI

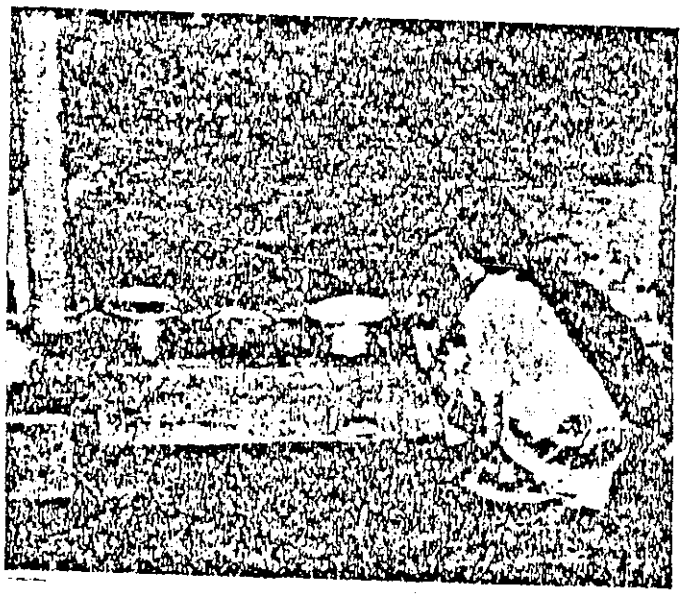


Fig 7

conventional stove was compared with the values when ASTRA CLE is used. This was carried out in 3 houses where conventional (A and C type) are used, the average fuel consumption rate was 1.31 kg/person/day this value is comparable to the fuel consumption of 1.23 kg/person/day in Dhenkanal. In ASTRA CLE, for the same period of study in 3 houses, the fuel consumption rate was [illegible] kg/day/person, SPC values in the conventional stove was 410 gms/kg as against [illegible] gms/kg in ASTRA CLE.

families having similar fuel with similar food habits were chosen for this study. The result also shows that only 31 percent of the fuel is saved. This could be considered as a realistic fuel saving in ASTRA CLE. It was quite intriguing to find that in the same ASTRA CLE in one time cooking experiment 7 percent fuel can be saved when three pots are used but the fuel saving was only 31 percent. On enquiry, it was found that [illegible] Amount of cooked to uncooked food varied largely and need of a new cook stove was itself questioned by users. Therefore a study on the food habit, number of dishes cooked per meal and quantities of meal [illegible] collected in 100 houses having conventional stoves and 100 houses having ASTRA CLE. The results are as follows:

Cooking practice and food habit

People in this region take a heavy breakfast with one cooked dish, and generally tea with milk and sugar as beverage before breakfast. For breakfast 'Dosa', 'Idli' and such dishes made out of rice and blackgram pulse flour are cooked. In addition, milk is boiled. After the morning work, a heavy lunch is taken during 1-2 p.m., which is generally the most important meal of the day. In the evening, [illegible]

light snacks are taken around 5 to 6 p.m. Last meal of the day is supper, taken after 8.p.m. Thus the cooking is carried out 4 times a day. The food during lunch and supper generally consists of rice, vegetable curry (boiled pulses+vegetables+spices) and cooked vegetables. In addition, dishes prepared out of yogurt is taken but this does not need heating except for boiling milk before making yogurt.

In figure 8,percentage of the number of dishes cooked at a time in the conventional stove and ASTRA CLE are given for all the 4 meals. In the conventinal stove when 3 dishes are cooked at a time more than one stove is used. However, in ASTRA CLE all the three can be cooked simultaneously. The practice of cooking three dishes simultaneouly seems to have changed. However during the evening the preparation, essentially only the first pot in ASTRA CLE is used.

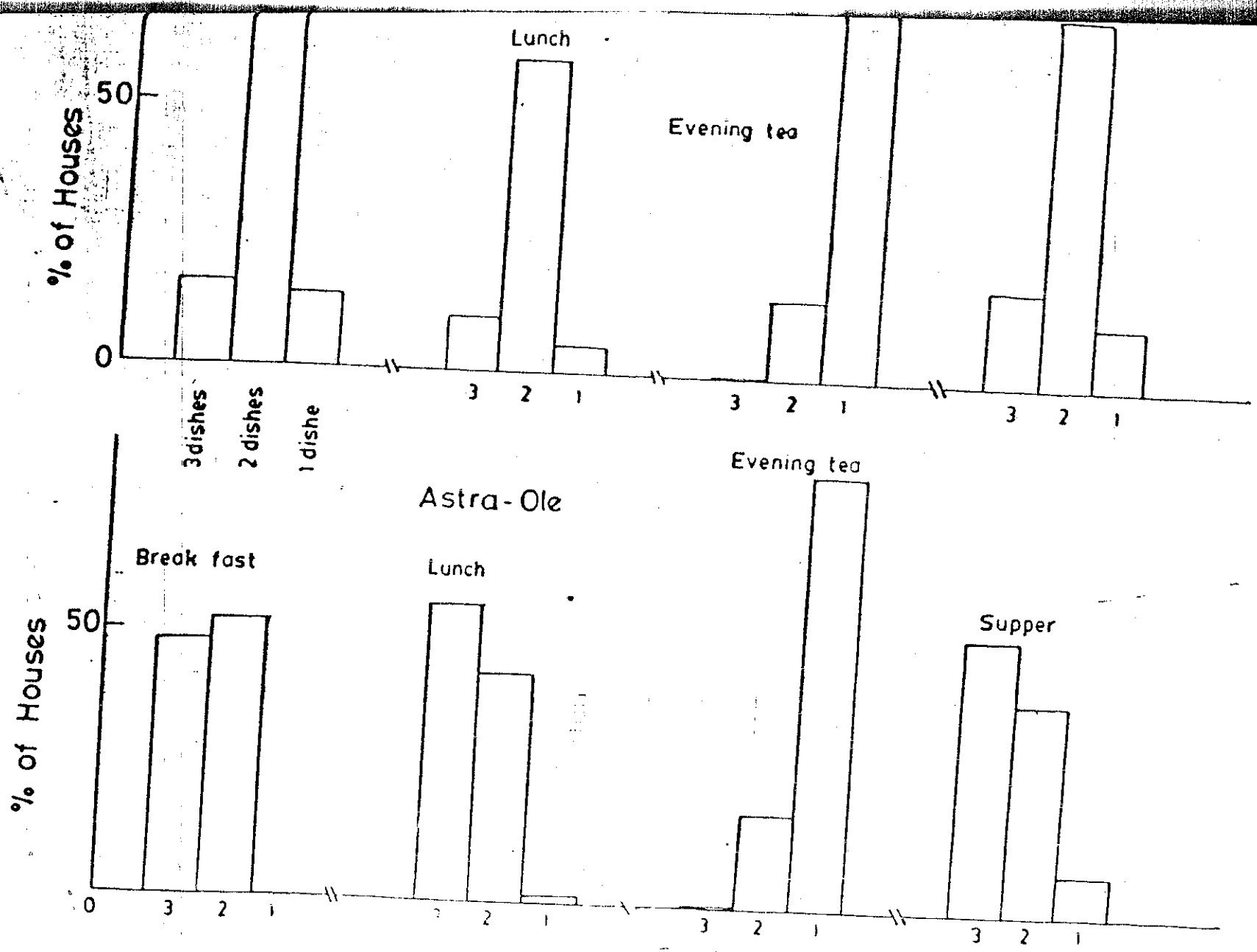
Quantity of food cooked for meal also varied greatly. Cooked food during lunch,supper,breakfast and evening tea were 1.81, 1.61, 0.75 and 0.43 kg respectively. Based on these data a realistic estimate of fuel saving in the ASTRA CLE is obtained.

Fuel Conservation - [illegible]

SFC values for one time cooking during lunch hours is found to be 172 gms/kg in ASTRA CLE when all the three pans are used for cooking.

$$\text{Let } Ef(j) = \frac{\text{Efficiency of } j \text{ th pan}}{\text{Efficiency of the 1 st pan}}$$

In ASTRA CLE, $Ef(1)= 1$, $Ef(2)=0.68$, $Ef(3)=0.4$ (sees table 3) &c the maximun efficiency factor $E=Ef(1)+Ef(2)+Ef(3)=2.08$. Let $c(j)=$ daily per capita consumption of cooked food for j th meal. Also let $p(i,j)=$ Proportion of families cooking i number of dishes in one meal at a time. It has been observed that if it is one dish, only 1st pot is


% of Houses
50
0
Lunch
Evening tea
3 2 1
3 2 1
3 2 1
3dishes
2 dishes
1 dishe
Astra-Ole
Break fast
Lunch
Evening tea
Supper
% of Houses
50
0
3 2 1
3 2 1
3 2 1
3 2 1

used, for two dishes 1st and 2nd holes are used and it it is three all 3 holes are used in the ASTRA OLE. Then, the effective efficiency factor:

$$= \sum_{i=1}^{3} \sum_{j=1}^{i} X(i) \times C(j) \times P(i,j)$$

Substituting the values given above, effective efficiency factor in ASTRA OLE has been found to be 1.35 as against the maximum value of 2.00. Hence the realizable percentage fuel saving in ASTRA OLE is 37. This value can now be compared with the actual 31 percent fuel wood saving observed in a weeklong measurements.

Conclusion

A simplified method of construction of fuel efficient ASTRA OLE has been introduced in Uttara Kannada villages.Although 57 percent of fuelwood could be saved through streamlined cooking practices, long term fuelwood saving is found to be atleast 31 percent. Additional advantages of this stove were its absence of smoke, shorter time for cooking, easy maintainance of fire and less fire hazard. The most of biomass especially agricultural residue could be burnt efficiently without smoke. These factors in addition to fuel saving has shown wide acceptibility of ASTRA OLE in Uttara Kannada villages and therefore holds out a great promise for conserving the much needed fuelwood throughout the peninsular India.

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