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Study on the Heat Utilization Efficiency of Improved Cookstoves

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ပိုမိုကောင်းမွန်သောမီးဖိုများ၏အပူစွမ်းဆောင်မှုလေ့လာခြင်း

ဦးသိန်းမြင့် (B.Sc. [For.] [Rgn.]) ဦးစီးအရာရှိ
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သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်းချုပ်

မြန်မာနိုင်ငံ၏ထင်းသုံးစွဲမှုနှင့် လိုအပ်ချက်ကိုလေ့လာပါက ထိပ်လန့်ဘွယ်ရာ မရှိသေးဟုဆိုရမည် ဖြစ်ပါသော်လည်း ဂရုပြုရမည့်ပြဿနာတစ်ရပ် အဖြစ်တွေ့ရှိရပါသည်။ တဘက်တွင်ထင်းနှင့်မီးသွေးစျေးနှုန်း မှာလည်းတတ်လျက်ရှိပါသည်။ ထိုပြဿနာများကို သစ်တောဦးစီးဌာနသည် နည်းလမ်းမျိုးစုံဖြင့် ကြိုးစား ဖြေရှင်းလျက်ရှိရာတွင် ပိုမိုကောင်းမွန်သောမီးဖိုများ ထုတ်လုပ်သုတေသနပြု စမ်းသပ်မှုလုပ်ငန်းလည်း တစ်ခုအပါအဝင် ဖြစ်ပါသည်။ စမ်းသပ်မီးသွေးမီးဖိုများကို သစ်တောသုတေသနဌာနရေဆင်းတွင် ထုတ်လုပ်စမ်းသပ်ခဲ့ပါသည်၊ မီးသွေးမီးဖိုပုံစံ(၂)မျိုးထုတ်လုပ်၍ လက်ရှိရောင်းဝယ်ဖောက်ကားနေသော မီးဖိုများနှင့်ယှဉ်၍အပူစွမ်းဆောင် မှုကိုလေ့လာခဲ့ပါသည်။ စမ်းသပ်မီးဖိုများ၏ အပူစွမ်းဆောင်မှုမှာ ပျမ်းမျ ၃၄ . ၀၇ % ရှိ၍လက်ရှိသုံးစွဲ နေသော မီးဖိုများမှာ ၃၁ . ၇၆ % သာရှိသည်ကိုတွေ့ရပါသည်။ စမ်းသပ်မီးဖိုများမှာ အပူစွမ်းဆောင်မှုပိုမို ကောင်းမွန်သော်လည်း စမ်းသပ်ချိန်တွင်ပင် အက်ကွဲ၍ ကြာရှည်မခံကြောင်း တွေ့ရှိရသည်။ သို့ပါ၍ မြေစေးအချိုးမှန်စပ်ခြင်းနှင့် ဖုတ်လုပ်နည်းသုတေသနများကို ဆက်လက်ဆောင်ရွက်သွားရန် လိုအပ်နေပါ သေးသည်ကို တွေ့ရှိရပါသည်။

Study on the Heat Utilization Efficiency of Improved Cookstoves

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Abstracts

The fuelwood situation in Myanmar indicates the intensity of fuelwood problem should be taken care of in the future, if not that alarming. At the same time, the cost of fuelwood and charcoal is escalating. The Forest Department has taken many steps in solving the fulewood problems, out of which includes research to disseminate appropriate technology for the efficient utilization of energy in domestic cookstoves. Some works on the design, production and testing of different types of charcoal stoves were carried out at the Forest Research Institute (FRI) in Yezin. Two major types of stoves with various sizes were made and their heat utilization efficiency (HUE) were evaluated in comparison with those existing commercial stoves. The HUE of newly designed charcoal stoves was 34.07% and that of commercial stoves was only 31.76%. Although the HUE of the newly designed stoves is encouraging the life span was found to be short and cracks appeared even at the time of testing. Some more works has to be carried out by using a better clay formulation and production/firing techniques.

Contents

1. Introduction

The Forest Department has estimated that 70% of the energy consumption in the country still come from woodfuel. Per household, 1.4 and 2.4 tons of fuelwood is used annually in urban and rural areas respectively. With this rate of utilizing, it is said to require 17 million tons of fuelwood and charcoal every year. It is foreseen that with the population growth of 2%, 25.2 million tons of fuelwood will be required by the year 2000. This indicates the intensity of fuelwood problem of the country in the future, if not that alarming. At the same time, the cost of fuelwood is escalating. Being noticed of this situation, the Government has taken every step in solving the problem. The operation carried out in the Forest Department includes:-

(1) Formation of plantations since 1978, some of 25% consisted of fuelwood plantations.
(2) Forming of village wood lots on the marginal land near the villages for the supply of fuelwood to the nearby villagers.
(3) Extension service to educate and encourage people in tree planting by distributing the seedlings. This is hoped to supplement timber and firewood for the community.
(4) Fulewood projects are signed with the UNDP body to help national effort in acheving the balance between supply and demand of fuelwood.
(5) Research on fuelwood plantations, namely on outturn, spacing, fertilization and introducing of exotic species has been carried out at the Forest Research institute (FRI) in Yezin.
(6) Research to disseminate appropriate technology for the efficient utilization of energy in domestic cookstoves has also started in the FRI.

The outcome of the last step is the research and development in improved cookstoves that has been started at FRI in past three years. As an initial work, teaditional commercial stoves are studies and some improved cookstoves are developed and tested. The Heat utilization Efficiency (HUE) of both the traditional and improved cookstoves are evaluated and compared.

2. Objectives

The major global objectives of the improved cookstoves in the descending order are

(1) increasing fuel efficiency in the household,
(2) decreasing smokiness,
(3) reducing deforestation
(4) saving money, and
(5) improving the status of women (6).

On the otherhand, the objectives of this research are as follows:-

(1) To increase fuel efficiency in the household,
(2) To reduce the annual consumption of firewood and thus ease the deforestation of national forests.
(3) To maintain or even elevate the energy ladder, ie. dung, crop residues, brush, wood, kerosene, heating oil and electricity.

3. Literature Review

Development of the one-stick-stove was initiated in 1987 at FRI in Yezin (2). At first the stove was made of gulvanised sheet which later on was replaced by locally available material-caly. Based on the limitted field trial in nearby public households, the result was quite encouraging. It is said that 50% of the fuelwood is saved, quick in cooking and the cost is reasonable. On the other hand, the stove cracks quite early and some improvement in raw material preparation is still needing.

Much of the work on the improved cookstoves has been carried out by the Regional Wood energy Development Programme (GCP/ RAS/ 131/ NET) under Food and Agriculture Organization of the United Nations. Some expert consultations, seminars, workshops training etc. are organized by this organization.

Supplement energy for rural development such as solar energy, biomass energy and other gaseous energy source also have become widely used (1).

Variety of cookstoves has been tried with the use of wood waste and agriculture waste. China, India, Bangladesh, Nepal and Sri Lanka are the good example of countries, involving in such activities (3). Biogas from tree leaves has also been tested in FRI, Yezin, and yet it is not feasible for practical use (4).

In Thailand, it is aimed to increase the Heat Utilization Efficiency of developed stoves over existing models by a minimum of 5-10%. It is estimated that annual consumption of firewood and charcoal may be reduced approximately by 2 million m^3/year by employing the efficient cooking stoves (5).

Countries, namely South and South East Countries have been involved in the development of improved cookstoves.

4. Materials And Method

Six pieces each of type “A” and “B” of existing commercially produced charcoal stoves were bought from local sale. These were imported from Pathein area. Type “A” was made of clay (mud) body enclosed in the gulvamized bucket and was designated as “Rucket Type”. Type “B” was made of clay (mud) along- “Clay Type”. Six different sizes of cookstoves were collected for both types. The samples of some stoves were shown in the plates and the different dimensions were given in table (1) below:-

Table (1). Measurement of commercial and improved stoves.

Sr. No.	Type	Top. Dia. cm	Firing cham-ber cm^3	Grate Dia. cm^3	Grate hold Dia. cm^3	Remarks
1.	A_3	35.0	26280	21.0	2.0	Bucket Type. commercial
2.	A_4	33.5	23660	19.5	2.3	
3.	A_5	30.5	15001	17.2	1.8	
4.	A_6	27.7	9720	15.2	1.8	
5.	A_7	26.9	7920	14.9	1.7	
6.	A_8	26.0	6990	14.0	1.7	
7.	B_3	27.5	22600	21.0	2.5	Clay Type.

						Commercial
8.	B_4	24.8	15790	19.5	2.2	
9.	B_5	23.0	10710	17.0	2.0	
10.	B_6	22.7	13560	17.2	1.8	
11.	B_7	21.3	8150	15.0	1.8	
12.	B_8	18.5	5380	14.0	1.8	
13.	C_{1-42}	26.0-30.8 28.7	2693-21974 8543	13.0-19.6 15.0	1.2/ 1.8	Clay Type.Developed
14.	D_1	33.0	14850	14.2	1.2/ 1.8	Clay Type.Developed
15.	D_2	30.5	14530	15.0		
16.	D_3	31.3	14140	14.0		
17.	D_4	33.7	15850	14.2		
18.	D_5	31.0	12830	15.5		
19.	D_6	31.0	14140	13.5		

Common sizes of stoves suitable for a normal family of 5 or 6 members only were studied.

Some improved cookstoves were designed and produced in FRI. Six pieces of type "D" and forty two pieces of type "C" were tested. The number of "C" type tested was over forty on account of the reason that this type had the design that seemed to last long and suitable for normal household. The major difference between the commercial stove and the developed stove are in design and the grate hold size. The new design had given more attention on the followings:-

(1) The stove rim was deeply slanted so that it can accommodate various sizes of pots and pans.
(2) Exhaust gap for hot air out-let is made to be in the limit of 0.5-1 cm.
(3) Top rim of the stove is always higher than the pot bottom to prevent heat loss by wind.
(4) Grate holes should be small and closely spaced. Diameter of grate holes should be in the range of 1.2-1.8 cm.

Adhering to the above criteria, the developed cookstoves were disseminated. They were shown in the plates and their respective dimensions were given in table (1) together with those of the existing commercial stoves. The kiln for firing the cookstoves was built in FRI and a potter-not a stove maker, was employed. The man thus employed had no expericence at all in stove making.

Equal amount of yellow clay and rice husk were thoroughly mixed and soaked for 12 hours. It was then beaten to become sticky. One third of the mixture thus obtained was air dried for 24 hours and burnt to hard solid blocks, which again was grinded into rough powder. The powder was then remixed with the remaining two portions of the beaten clay and rice husk. Then the mixture was thrown on a simple potter's wheel to from the stove main portion. The grates were also made and both were air dried for three days. Then the two portion were put into the kiln for firing. Firing normally took 3 days and 2 nights. The use of yellow clay was made into type "C" stoves and white clay from Yamethin was used to make "D" type stoves.

The raw material clay available around FRI was of poor quality as compared to the one used for commercial production of charcoal stoves in Pathein. The clay around FRI contained more sans as could be seen in the table below.

Sr. No.	Source of sample	Sand %	Sitt %	Clay %
1.	FRI sample	35.7	18	41.4
2.	Pathein sample	7.5	19	68.4

* Analysed by the soil laboratory in the FRI.

The two types of commercial stoves and the other two types of developed stoves were thus tested on their heat utilization efficiency (HUE) by water boiling method.

The standard formula for evaluating the heat utilization efficiency was as follows:-

$$HUE = \frac{\text{Total quantity of heat consumed by water}}{\text{Total quantity of heat given off by fuel combustion}} \times 100$$

$$= \frac{M_1 C_p (T_2 - T_1) + (M_1 - M_2) L}{M_f H}$$

where, HUE = Heat utilization efficiency in percentage
M_1 = Weight of water in gm
M_2 = Weight of remaining water in gm
M_f = Weight of fuel in gm
C_p = Specific heat capacity of water 1 cal/ gm. ˚C
T_1 = Initial temperature of water at test, ˚C
T_2 = Temperature of water at boiling, ˚C
H = Calorific value of fuel, 6960 cal/ gm.
L = Latent heat of vapourization of water = 540 cal/. gm

Water at 28˚ C was taken and testing was done under ambient room temperature and no wind. The pot lids were opened during the test. Duration of test included the time to bring the water to boil and continue boiling for 30 minutes or more. The amount of water used was normally 3700 gm and the amount of fuel (charcoal) depends on the size of stove. In range from 200 to 400 grams.

So as to study the effect of the grate hole, two sizes (1.2 and 1.8 cm in diameter) were tested with type “C” and “D” stoves.

5. Results

The mean values of the heat utilization efficiency of the stoves tested are given in table (3) below: -

Table (3). The HUE of different types of stoves

Sr. No.	Stove type	Mean HUE %	Standard deviation
1.	A	32.41	2.35
2.	B	31.11	3.13
3.	C	35.64	2.10
4.	D	32.51	3.17

To observe the performance between different types of stoves, student "t" values are calculated and the results are given in table (4).

Table (4) Student "t" values of HUT for different types of stoves.

Between types	n	$\bar{x}$	S^2	S	t
A	89	32.41	14.49	3.779	2.126*
B	67	31.11	14.01		
A	89	32.41	14.49	3.046	-6.971**
C	84	35.64	3.76		
A	89	32.41	14.49	3.930	-0.169
D	88	32.51	16.42		NS
B	67	31.11	14.01	2.881	-9.599**
C	84	35.64	3.76		
B	67	31.11	14.01	3.920	-2.203**
D	88	32.51	16.42		
C	84	35.64	3.76	3.990	6.41**
D	88	32.51	16.42		

Note:-

NS = Not significant
* = Significant at 95 % level
** = Highly significant at 95% level

Test results of performance by different grate holes in type "C" and "D" are also analysed and the respective "t" values are given in table (5).

Table (5). The "t" values of two different sizes of grate holes

Type of stove	Grate hole	n	$\bar{x}$	S^2	S	t
C	1.2 cm dia	8	31.66	10.05	2.82	0.84 NS
C	1.8 cm dia	8	32.84	5.91		
D	1.2 cm dia	42	35.71	4.543	1.965	0.326 NS
D	1.8 cm dia	42	35.57	3.178		

NS = Not significant.

6. Discussion

In tables (3), the average HUE of the traditional and the designed stoves are found to be 31.76% and 34.07% respectively. An increase of 2.31% only is achieved. It could be side to be encouraging and yet only about half of the targeted in increment is observed. The target is normally aimed at an increment of 5% in HUE.

Therefore it should be mentioned that the new improved design is found to be better nevertheless some more work should be carried out to get more improvement.

It can also be seen in table (3) that the difference in performance between different sizes of same type is rather high. This leads to point out that the difference in stove size has some influence on the HUE, which is not expected before hence. More detail study on the size effect has to be carried out later.

Studying the table (4), the performance between stove type "A" and "D" is not significant whereas between the rest of the pairs, they are significant or rather highly significant. Improved type "C" is better than both traditional stoves "A" and "B" or even better than newly designed stove "D". Stove "D" type has better performance than commercial "B" type alone. It is of no difference to "A" or even lower in HUE than "C" type. It can therefore be assumed that type "D" is not of a good design.

It is suggested that, grate hole should be in the range of 1.2-1.8 cm in diameter and also closely spaced. Table (5) indicated that the performance of both sizes of grate hole has no influence on the HUE. The reason for such finding is that, although the holes are in different sizes, they are not closely spaced-being aware of the fact that the grates may break easily. It is of great importance to find a hardy material to make great so that holes can be made as close as possible without breaking easily.

As a whole, the research on improved cookstoves should be regarded as technically encouraging. On the other hand, performance is not in a satisfactory condition as has been expected. In most of the solves cracks appear even at the time of testing.

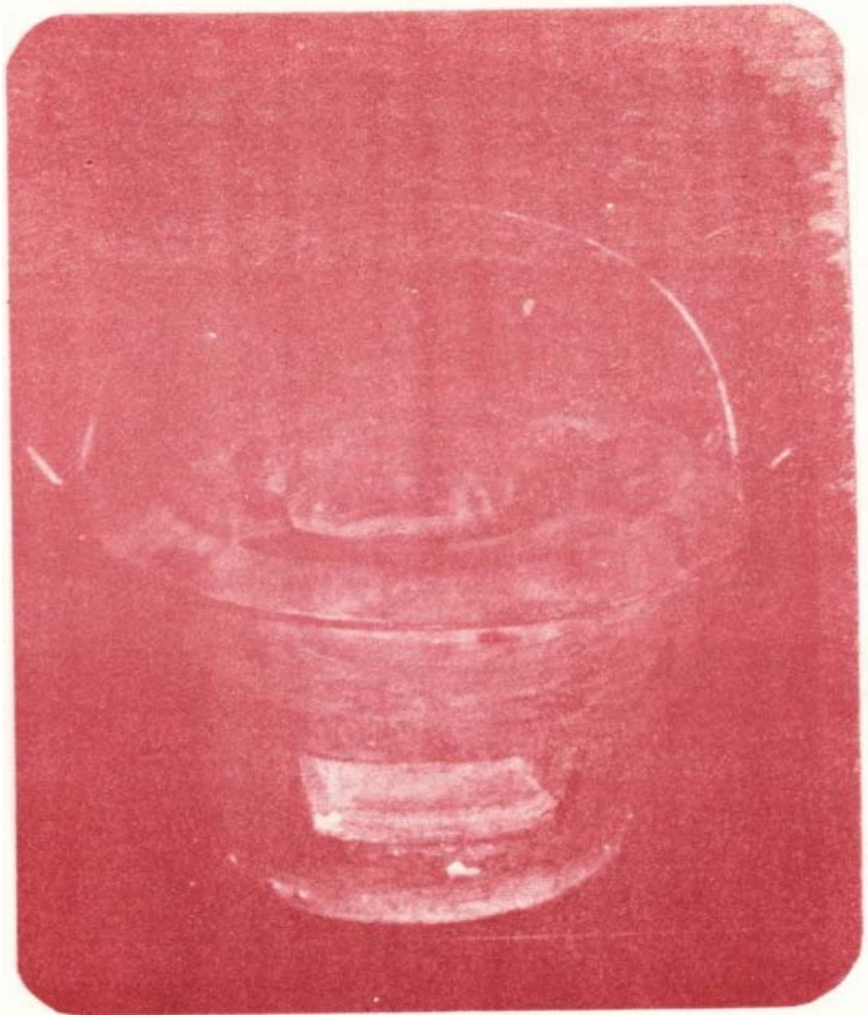
7. Conclusions

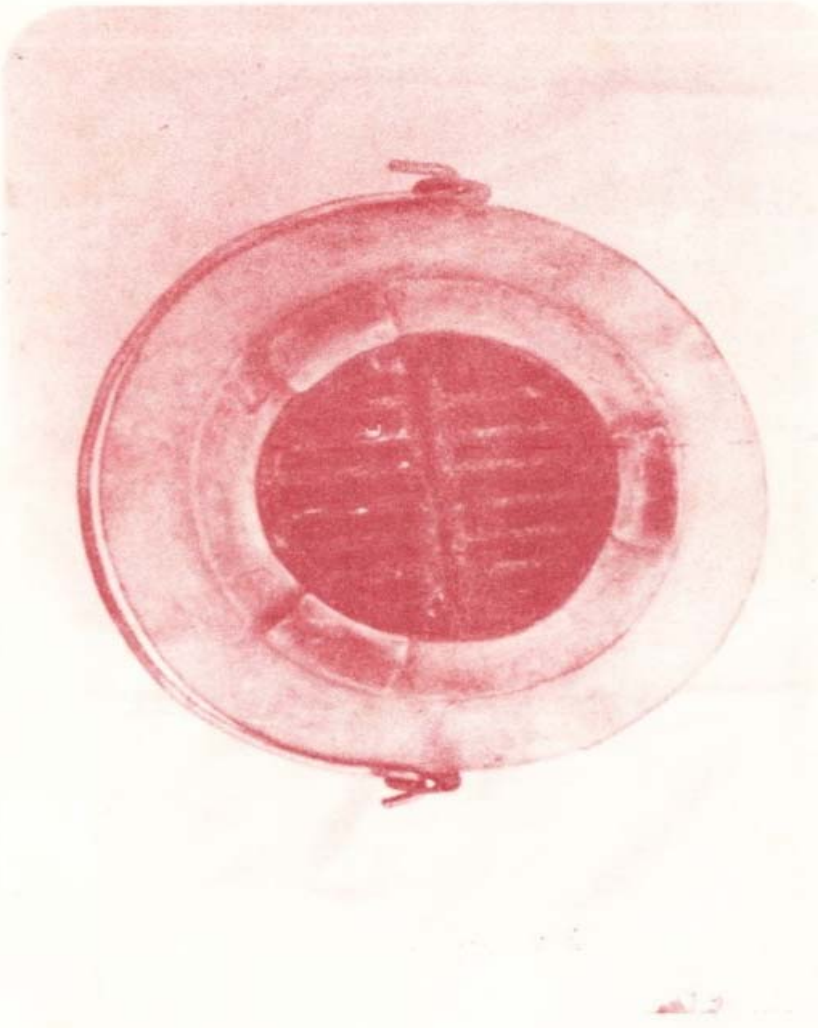
The raw material available around FRI is not of suitable quality for stove making. Some clay from Pathein area should be imported and more work should be done namely in clay mixture. The life span of the cookstoves can only then be prolonged.

The FRI staff is not much conversant with the technical know-how on stove making and further training should be given to the appropriate members of the Institute.

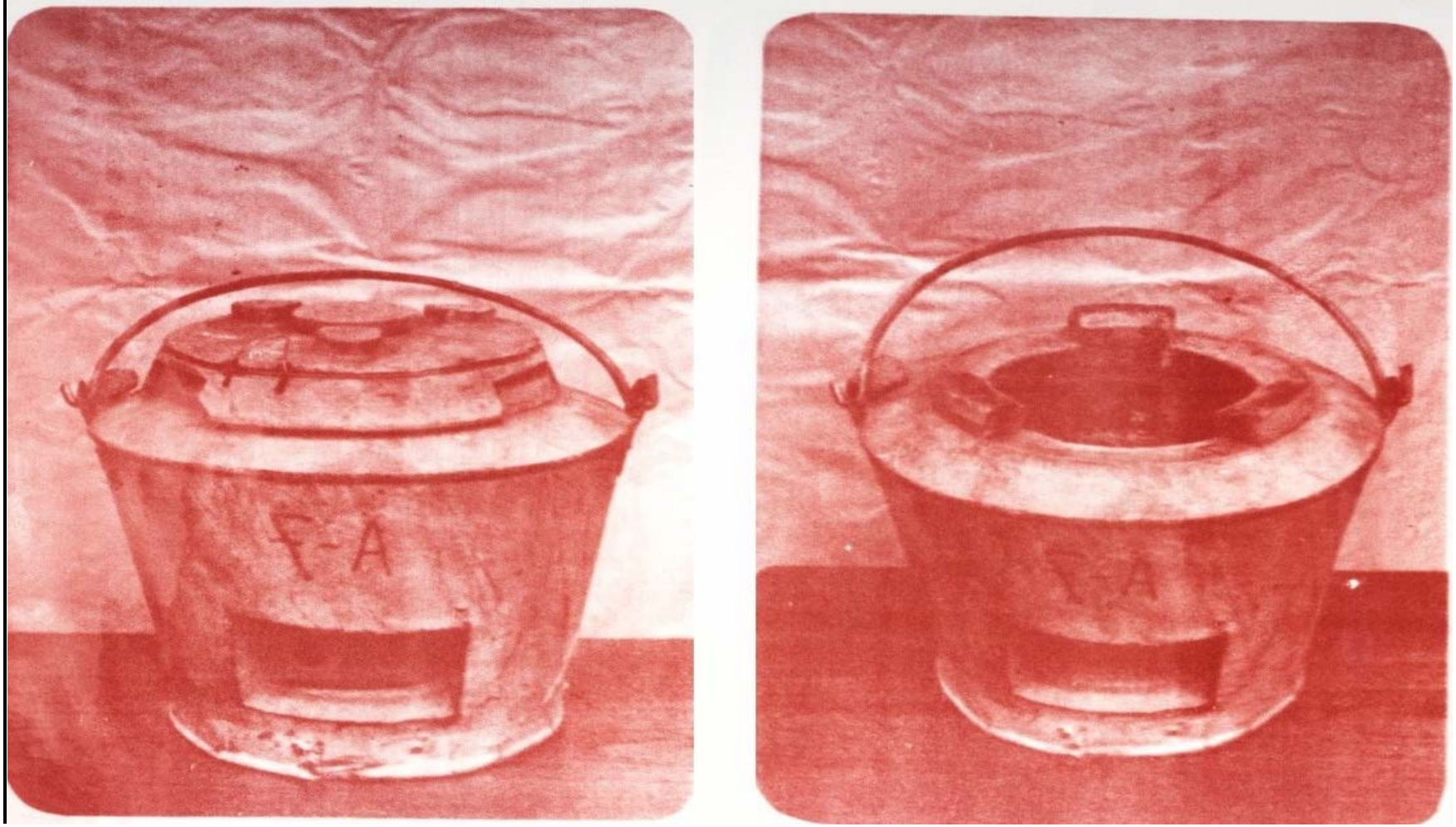
Although the outcome of the research is not at a satisfactory level, it should be regarded as fruitful at such initial stage. Some support in manpower and training for improved cookstove Programme is duely needed. With the introduction of improved cookstoves, the present demand of fuelwood and charcoal can greatly be reduced and the impact will be significant. The method of dissemination should also be improved. Lastly, it is desirable that, the forest Department, Department of energy and Department of Cottage Industries should coorperate in such a national programme.

Commercial Charcoal Stoves, Pathein A(5)

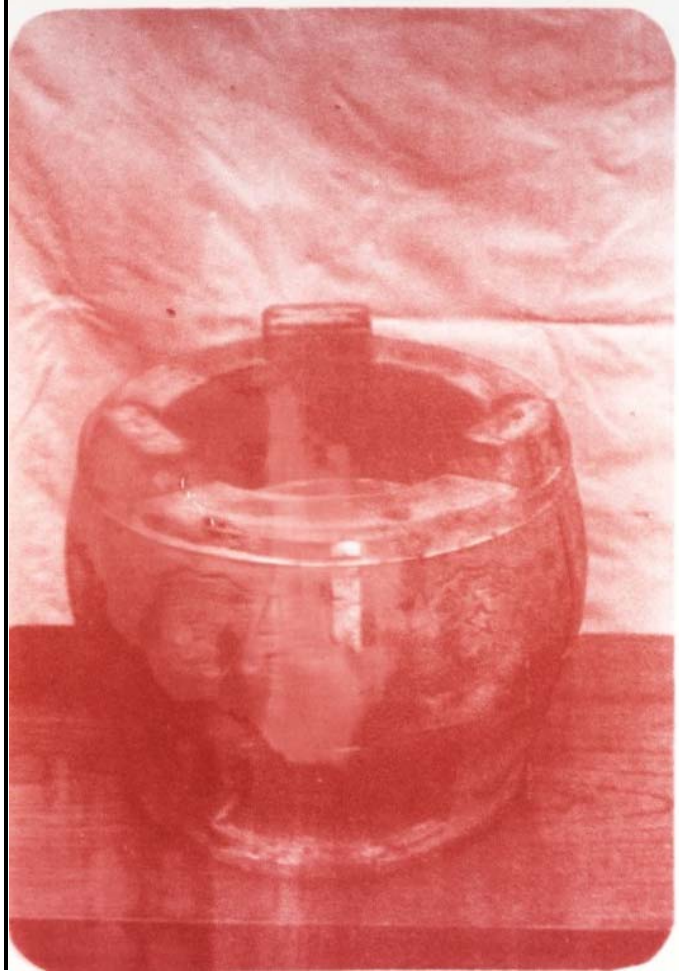


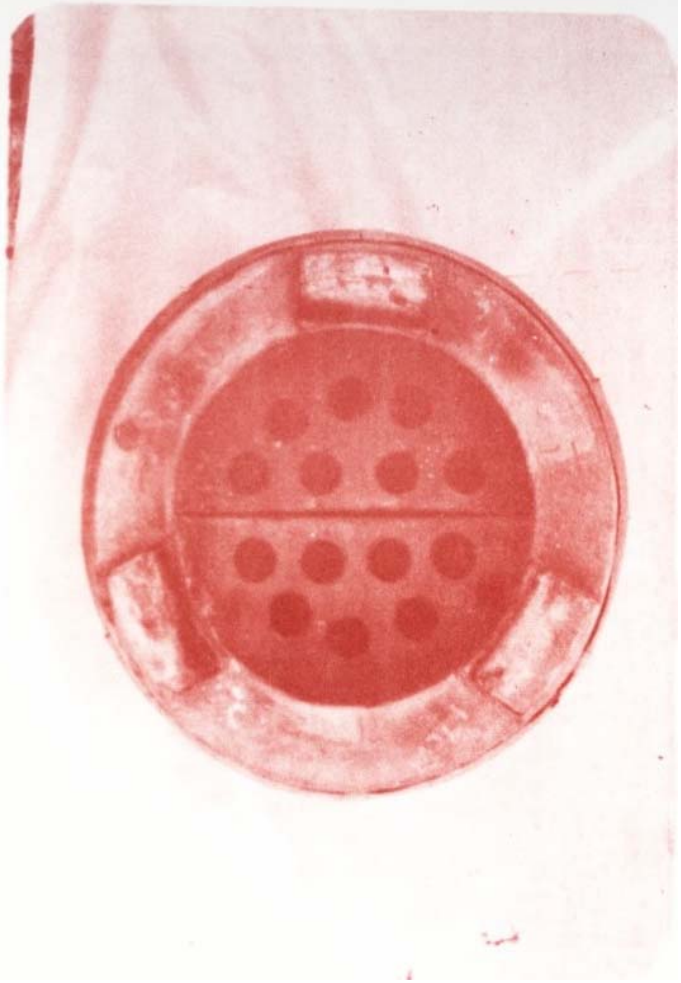


Commercial Charcoal Stoves, Pathein A(7)



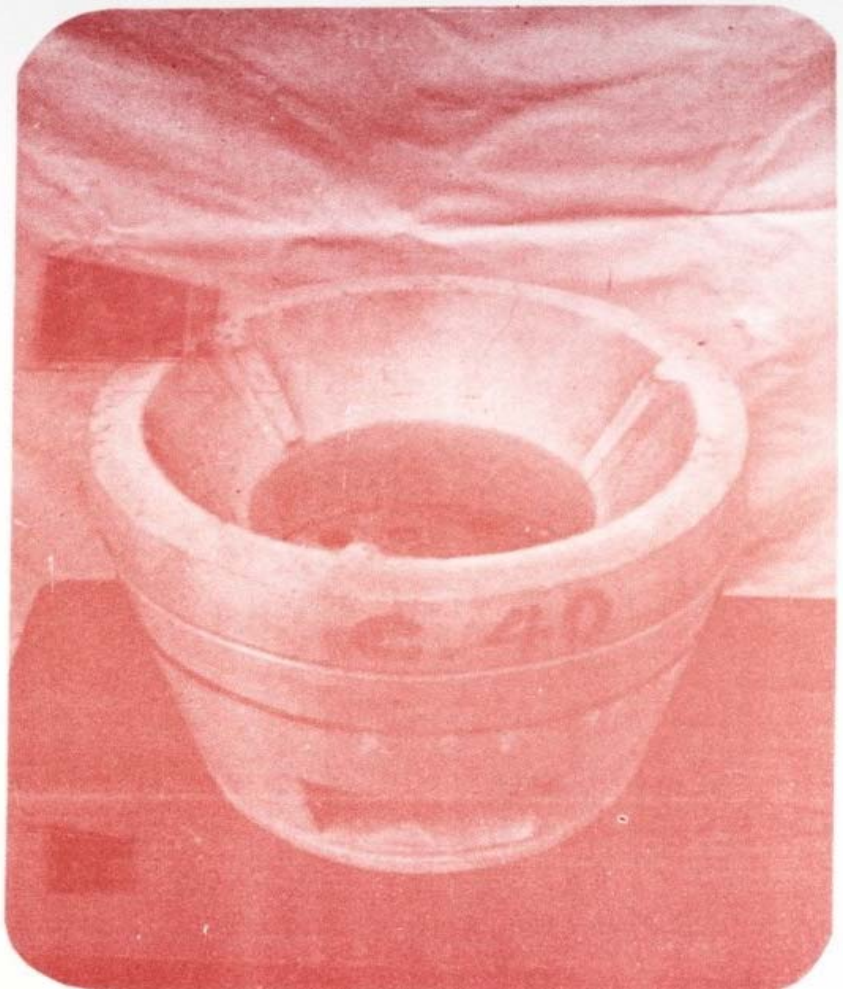
Commercial Charcoal Stoves, Pathein B(4)

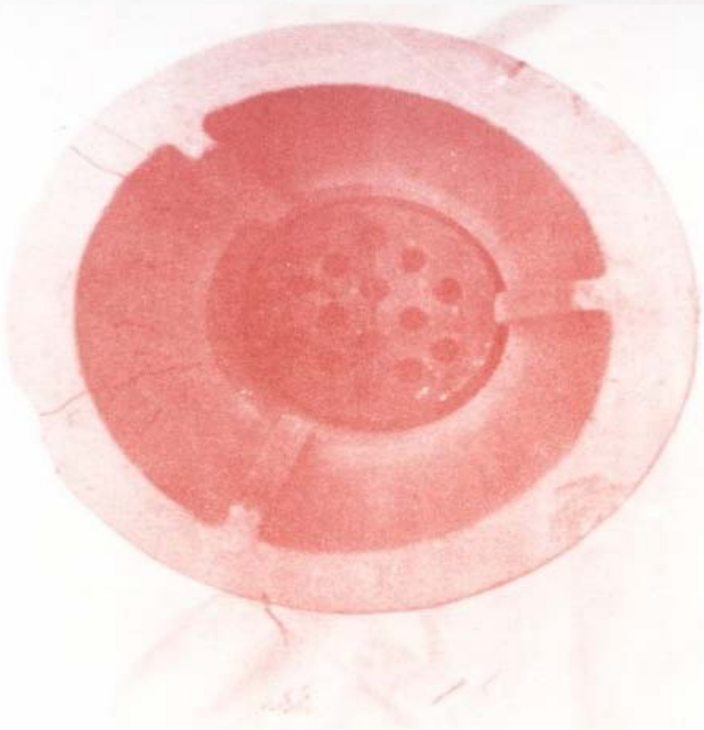




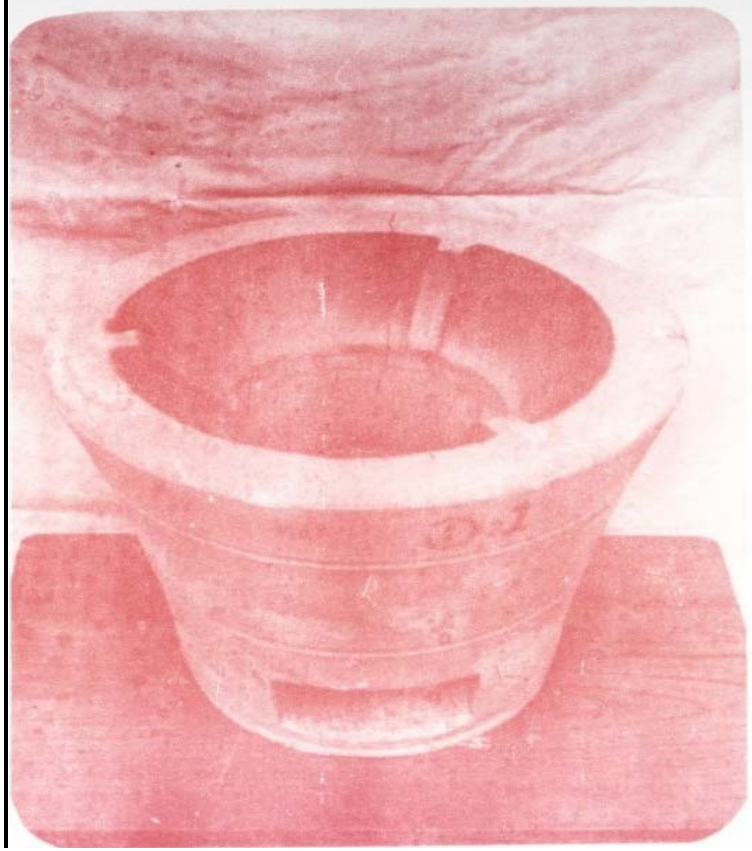
Commercial Charcoal Stoves, Pathein B(7)

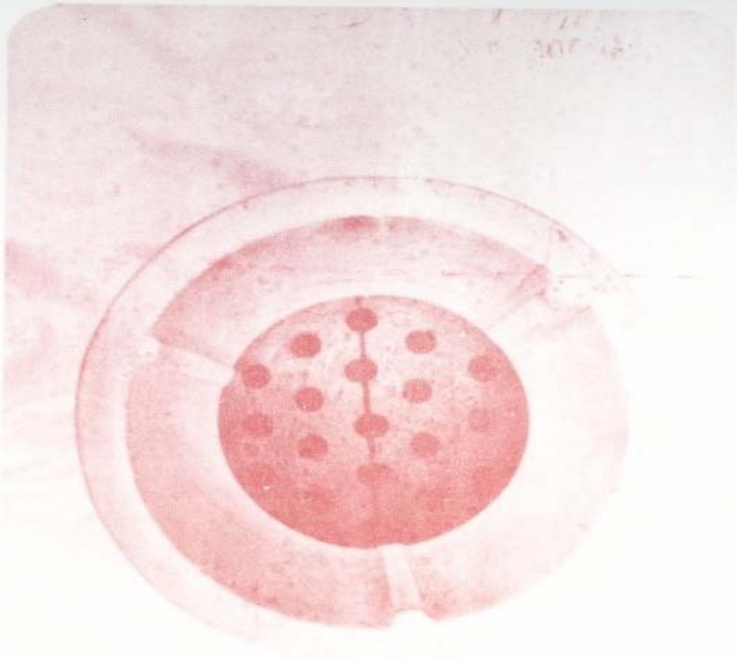
Improved Stoves. F.R.I. C(40)





Improved Stoves. F.R.I. D(1)

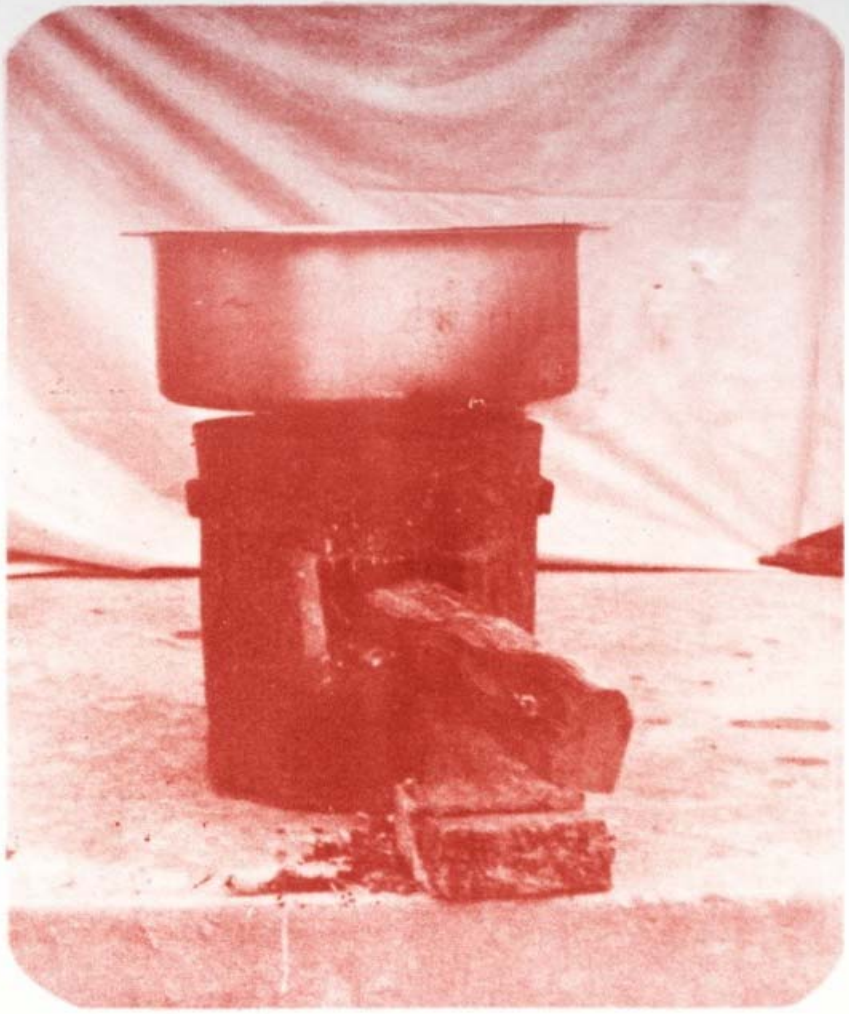




Stove Burning Kiln, F.R.I

One stick firewood stove, F.R.I

One stick stove, F.R.I



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