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ENERGY EXCHANGE EFFECTIVENESS ENHANCEMENT EVALUATION IN A KEROSENE STOVE

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Abstract— **Among the Energy Resources, Liquid fuels are the most valuable indispensable part of our existence. It has satisfied a number of our needs starting from cooking to propelling Airplanes. In the present Investigation, Kerosene forms the basis of interest. It is employed primarily as a fuel and illuminant. The scope of the present investigation is to increase the conservation of Kerosene. This can be achieve by enhancing the mode of heat transfer in a conventional Kerosene stove. As it is well known that radiative heat transfer co-efficient is greater than the convective heat transfer co-efficient. In order to achieve this, model of Nichrome wires are used with existing Kerosene stove.**

The success of endeavour can be determined by the fact that if radiation is attained for a given amount of fuel burnt, the heat transfer by radiation would be in greater excess than the heat transfer through convection, there by resulting in saving of the amount of fuel used for same heat load. The investigation is successful because it made possible to achieve an increase of around 6-7 % in efficiency, which in turn saves approximately 1 million tons of Kerosene a year globally. In monetary terms this is equivalent to a saving of around 9000 millions of Indian rupees.

***Index Terms*— Energy, Heat transfer, Kerosene, Nichrome, Radiation.**

I. INTRODUCTION

Liquid fuels form the most valuable indispensable part of our existence among the Energy Resources. They have satisfied a number of our needs right from the cooking to driving our cars and propelling the airplanes. They have added a whole new dimension in our lives. Liquid fuel in the form of petroleum is the most coveted commodity. This petroleum is made up of many fractions viz. Naptha, LPG, Gasoline, Kerosene and lubricating oil.

In the present Investigation Kerosene form the basis of interest. Kerosene is the fraction obtained from the atmospheric distillation [2] unit during the processing of crude petroleum. It is obtained in between the Gasoline and Diesel fractions. It is employed primarily as a fuel and illuminant. Kerosene as a fuel finds usage on the domestic front as medium of cooking. It is estimated that in our country around 35-40 % of the population uses kerosene. As it is cheaper compared to LPG, it is prominently found to be used by economically weaker classes. It is also estimated that a meager saving of just 1 % in Kerosene, would save our country about rupees 750 millions.

The scope of the present Investigation is to ensure the conservation [3, 4, 7] of Kerosene. This can be achieved by enhancing the mode of heat transfer in a conventional Kerosene stove. It is very well known that, radiative heat transfer co-efficient is greater than the convective heat transfer co-efficient. In this Investigation it is intend to establish radiation as the dominant mode of heat transfer. In order to achieve this, a hemispherical model made of Nichrome wire, placed on the outer shroud of the Kerosene stove. It radiates heat as and when it begins to glow after being heated by the naked flame. Since the surface area exposed in this case is larger, the heat transfer co-efficient is expected to be greater..

II. MATERIALS AND METHODS

A. Experimental Setup

The objective of the present Investigation is to enhance and evaluate the energy exchange characteristics in Kerosene stove. This is achieved by incorporating various modification and innovative models made of Nichrome wire (Canthal-- D) into the original stove configuration, which enhances the energy exchange characteristic [5,6] thereby saving energy conserving fuel. The Kerosene Stove used during the course of the Investigation has a capacity of 3 liters and fuel consumption of 168 g/hr in high wick level, 96 g/hr at medium wick level and 60 g/hr at low wick level. It has 10 wicks and also has a wick regulator to vary heat output as desired. The Kerosene Stove used has various shrouds. This arrangement causes a steady blue flame and results high heat output. The schematic representation of the Experimental Setup is shown in Fig.1.

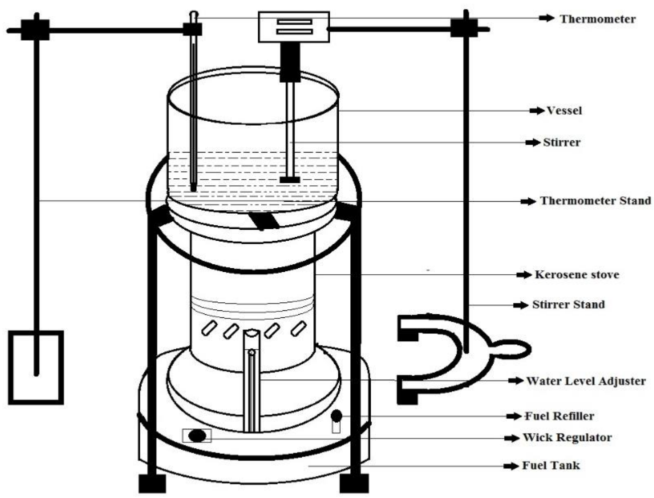

Fig.1. Schematic representation of the set up

The shrouds designed and used for the experiments are shown in Fig.2.

Fig.2. Modified Shrouds

Fig3. Flat Circular Concentric Cylindrical Model.

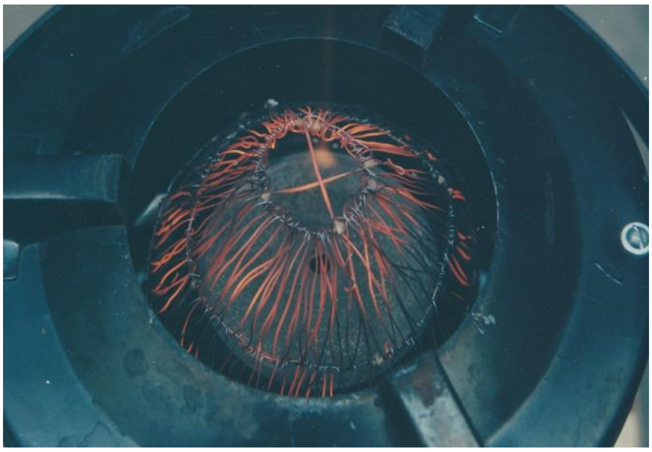

Fig.4. Hemispherical Model (25 Gauge)

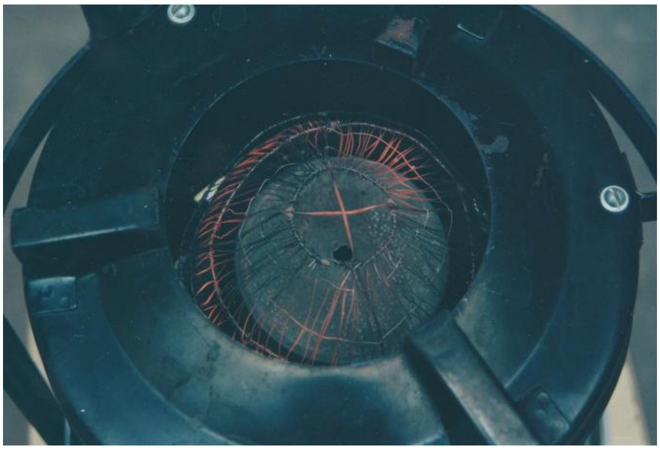

Fig.5. Hemispherical Model (30 Gauge)

Fig.6. Hemispherical model (33 Gauge)

B. Experimental Procedure

The experiment is carried out in three different phases. In the first phase of experimentation, the original configuration of the Kerosene Stove is maintained and the experiment is carried out with different heat loads [8] of 1 litre, 2 litres and 3 litres of water at different wick level of high, medium and low. A thermometer with a least count of 1 °C is used to monitor the temperature up to 70 °C. The time taken for every 5°C rise in temperature is observed.

In the second phase of Investigation a flat circular model (Fig.3) followed by cylindrical model (two flat concentric circular model joined together providing a gap of 1 cm between them) made up of Nichrome wire are tested. However, this model proved to be inefficient and hence a new model in the form of hemispherical dome has come into existence.

In the third phase of Investigation, experimentation is carried out on the hemispherical model and is found to be efficient. So, further tests are conducted on the models made up of different gauge (25gauge (Fig.4), 30gauge (Fig.5) and 33gauge (Fig.6) of Nichrome [9] wire. The findings are tabulated and further calculations are performed
.

III. RESULTS AND DISCUSSIONS

Extensive experiments are carried out with various models including the original configuration of the Stove. During the experimentation, it is observed that the efficiency increases with the use of a model as compared to the original configuration. This, deduced the fact that time taken by the volume of water to attain 70 °C is less, compared to the case when no model used. This led to a conclusion that use of model lead to an increase in efficiency.

In the first phase, experiment is limited to the original configuration without any model. The efficiency calculated for this phase is around 30 - 35 %.

The second phase comprised of testing of various models under diverse condition and the results obtained aren't too high. It is due to the fact that these models acted as heat sink and hence there is no appreciable rise in efficiency. These models therefore gave way to the hemispherica1 model, which has largest surface area among the entire model.

In this phase various models were fabricated and experiments were carried out for high, medium and low wick levels. It was observed that efficiency increased for high wick level but it dropped for low and medium wick levels. This drop is attributed due to irregular heating pattern. It is these ambiguous result which prompted to experiment with the various thickness of the wire used for the fabrication of different model. The results obtained are given in Table 1 and Table 2 respectively.

The variation of temperature with time for different heat load condition is shown in Fig.7 and the variation pattern of thermal efficiency with temperature for the kerosene stove with original configuration is shown Fig.8.

The variation of temperature with time for the model with original configuration is shown in Fig.9 and that of the thermal efficiency is shown in Fig.10.

It is observed that energy requirement for the original configuration is more compared to the configuration with the model under same heat load conditions. It is also observed that the thermal efficiency of the Kerosene stove increases with the modification of the model.

Thermal efficiency [10] of the original configuration of the Kerosene stove as well as Kerosene Stove with models is calculated using the equation.

$$\eta = \frac{Heat\ Absorbed}{Heat\ Liberated} \times 100 \quad (1)$$

$$\text{Heat Absorbed } = mC_{pl}(t_1 - t_2) \quad (2)$$

Where,

$m_l =$ Mass of heat load (water), Kg
$C_{pl} =$ Specific heat of heat load, J/Kg. °C
$t_1 =$ Initial temperature of heat load, °C
$t_2 =$ Final temperature or heat load, °C

$$\text{Heat liberated } = m_f C_{pf} \quad (3)$$

Where,

$m_f =$ Mass of fuel (kerosene) burnt, Kg
$C_{pf} =$ Calorific Value of fuel (kerosene), MJ/Kg

Nomenclature:

η *Thermal efficincy*
m_l Mass of heat load (water)
C_{pl} Specific heat of heat load
t_1 Initial temperature of heat load
t_2 Final temperature or heat load
m_f Mass of fuel (kerosene) burnt
C_{pf} Calorific Value of fuel
°C Degree Celsius

Table1. Original Configuration (Wick Level High), Room Temperature =26 °C

Sl No	Temp (°C)	1 Litre		2 Litre		3 Litre	
		Time (Sec)	η (%)	Time (sec)	η (%)	Time (sec)	η (%)
1	30	27	28.58	71	21.74	88	23.31
2	35	57	30.40	130	26.70	153	34.05
3	40	85	31.77	189	28.58	212	38.22
4	45	110	33.32	248	29.56	285	38.59
5	50	135	34.30	309	30.36	301	38.81
6	55	160	34.97	371	30.16	434	38.68
7	60	188	34.89	435	30.36	511	38.61
8	65	213	35.32	495	30.46	582	38.79
9	70	243	34.93	553	30.70	655	38.88

Table2. Hemispherical Model (33 Gauge, Wick Level High), Room Temperature =26 °C

Sl No	Temp (°C)	1 Litre		2 Litre		3 Litre	
		Time (Sec)	η (%)	Time (sec)	η (%)	Time (sec)	η (%)
1	30	22	35.08	36	42.88	43	53.84
2	35	48	36.18	73	47.57	105	49.61
3	40	66	40.93	119	45.40	176	46.04
4	45	91	40.62	165	44.43	250	43.99
5	50	114	39.13	212	43.68	327	42.48
6	55	143	39.13	263	42.55	400	41.96
7	60	170	38.59	313	41.92	468	42.05
8	65	206	36.52	369	40.78	557	40.53
9	70	240	35.37	430	39.49	646	39.43

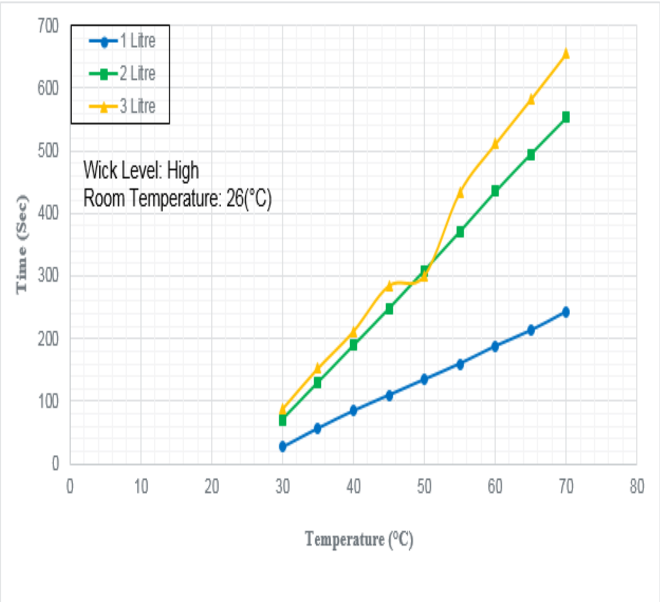

Fig.7. Variation of temperature with time for original configuration of the Kerosene stove

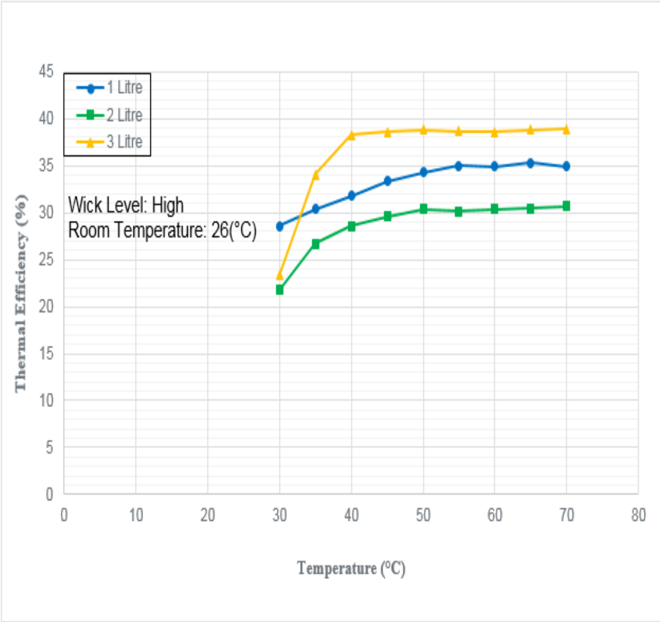

Fig.8. Variation of thermal efficiency with temperature for original configuration of the Kerosene stove.

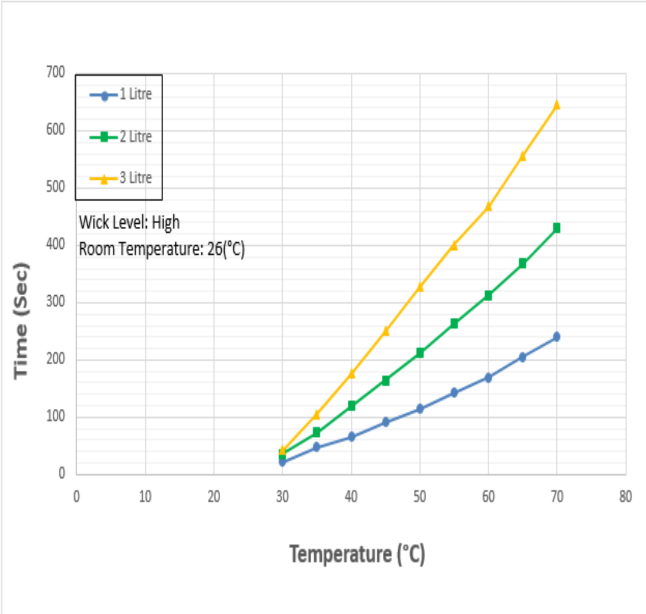

Fig.9. Variation of temperature with time for Hemispherical Model configuration of the Kerosene stove.

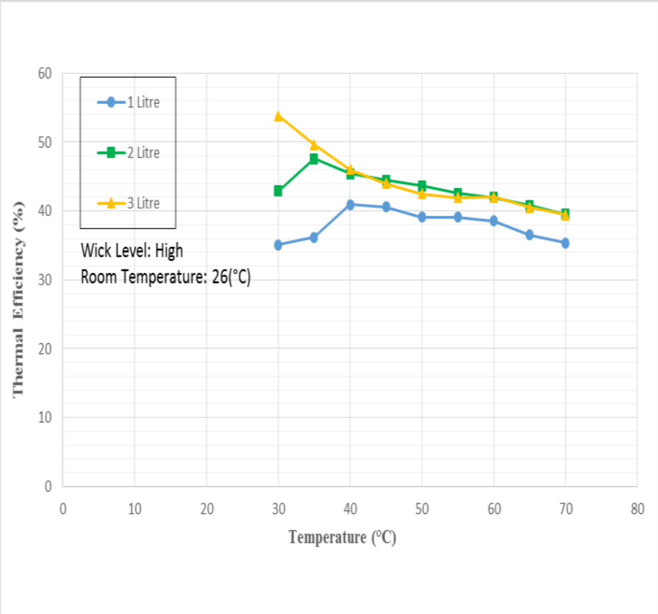

Fig.10. Variation of thermal efficiency with temperature for Hemispherical Model configuration of Kerosene stove

IV. CONCLUSIONS

It is concluded that the 33 gauge hemi spherical model is the most efficient amongst all model used for the investigation. The investigation was successful because it was possible to increase the overall efficiency by around 6-7 % by using the various configured models as compared to that of the original configuration. These translate into a saving of approximately 1 million tons of Kerosene in a year globally. In monetary terms this is equivalent to a saving of around 900 crore of rupees.

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