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Alternative Fuel Option for Kerosene Wick Stove: Blended Ethanol (20%) and Kerosene (80%)

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Abstract: *To solve the energy crisis, the search for alternative fuels is extensively important. Alternative fuels selected should be renewable, sustainable, and eco-friendly. In India, kerosene is also used as fuel in cooking stoves. Kerosene contains impurities like sulphur, aromatics, and hydrocarbons, which cause environmental degradation. In this experimental investigation, blends of ethanol and kerosene were used as an alternative fuel in a kerosene wick stove without any modification to the stove design. The blends tested were 5%, 10%, 15%, and 20% ethanol in kerosene. The experimentations have been carried out to obtain comparative measures of thermal efficiency and fuel consumption rate. The values of thermal efficiency and fuel consumption rate for blended fuel were found to be comparable with kerosene. The maximum value of thermal efficiency was obtained with a blend containing 5% ethanol while the minimum value was obtained with reference fuel. The fuel consumption rate for the blend containing 10% ethanol was found to be maximum.*

Keywords: Wick stove, Kerosene, Eco-friendly fuel, Ethanol, etc.

I. INTRODUCTION

Environmental pollution and fossil fuel depletion are matters of concern around the world. To solve tackle these problems, the search for alternative fuels has become significantly important. Alternative fuels selected should be renewable, sustainable, and eco-friendly. In India, kerosene is also used as fuel in the cooking stove. Kerosene stoves have replaced traditional wood-based appliances that are unhealthy and inefficient. However, kerosene itself also contains impurities like sulfur, aromatics, and hydrocarbons which cause pollution. On burning, it also produces a very unpleasant smell. Its smoke emissions create various respiratory problems. Kerosene is a thin, clear liquid formed from hydrocarbons. It is obtained from the fractional distillation of petroleum between 180°C and 250°C, resulting in a mixture of carbon chains containing 10 to 16 carbon atoms [1].

It is widely used to power jet engines, for heating and lighting. It is also used as fuel in wick stoves or pressure to cook food in India. Some of the fuels that can be used in cooking stoves are gaseous fuels like biogas, solid fuels like wood, charcoal, and liquid fuels like vegetable oils and ethanol. The use of liquid fuels is preferable to solid and gaseous fuels due to their high energy content, transportability, storability, and availability [2]. However, due to high viscosity and gumming tendency, vegetable oils are not extensively used on the cooking stoves. These disadvantages are not found in ethanol and thus make it an attractive alternative fuel. Ethanol can be produced from renewable energy sources such as sugarcane, corn, barley, and many other types of waste materials. Also, it has clean combustion. Ethanol has a lower calorific value and density as compared to kerosene.

TABLE 1: Calorific Value and Density of Test Fuels

Property/ Fuel	Calorific Value (MJ/kg)	Density (g/cm3 at 30°C)
Kerosene	43.5	0.820
Ethanol	26.9	0.785

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This experimental investigation aims to study the effect of using various blends of ethanol and kerosene on the performance of a kerosene wick stove. Pure kerosene was used as a reference fuel. These blends were prepared on a volume basis. The blends tested were 5%, 10%, 15%, and 20% ethanol in kerosene.

The following nomenclature is used in this work: K: Kerosene; E05: 5% volume of ethanol and 95% volume of kerosene; E10: 10% volume of ethanol and 90% volume of kerosene; E15: 15% volume of ethanol and 85% volume of kerosene and E20: 20% volume of ethanol and 80% volume of kerosene. The fuels used for entire testing belonged to the same supply, to avoid the unnecessary introduction of any variation during experimentation.

The experimentations have been carried out to obtain comparative measures of thermal efficiency and fuel consumption rate. All experiments were carried out on an unmodified stove.

II. EXPERIMENTAL METHODOLOGY

The experimental setup is shown in Fig. 1. It consists of a weighing balance, a kerosene wick stove, a standard aluminium vessel, a stirrer, and an alcoholic thermometer. The experimental setup consists of a capillary-fed wick stove. The test stove has 8 wicks of woven cotton placed in a holder such that they can be moved up and down by a control lever or knob. Wicks emerge into an annular space surrounded by two concentric perforated steel walls (the flame holder), which are spaced slightly wider than the wick thickness. The lower ends of the wicks are dipped into kerosene. The stove is lit by removing the perforated steel flame holder raising the wicks and lighting them. The holder is then placed again. The flame fills the gap between the two walls of the holder and emerges at the top of the stove. The flame can be raised or lowered by operating the knob, when raised the flame burns more intensely and vice versa.

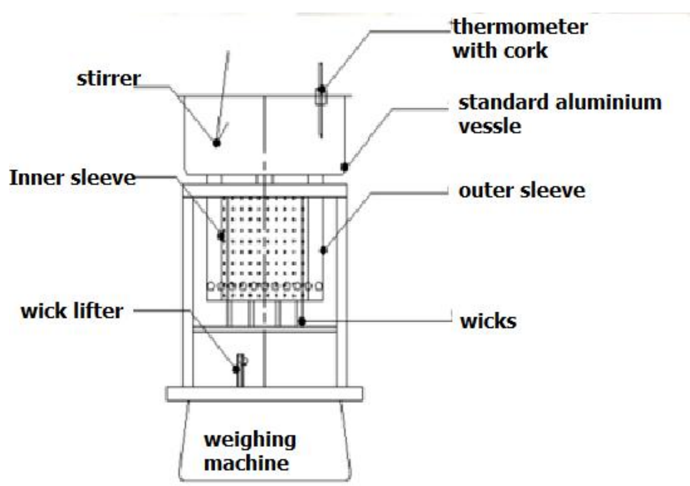

Figure 1: Experimental Setup

The technical specifications of the test stove are shown in TABLE 2.

TABLE 2: Technical Specification of Test Stove

Make	Sunrise
Manufacture	Romer Manufacturing Company, Mumbai, Maharashtra
Stove Type	Capillary fed, multi-wick
Weight*	1 kg (when empty)
Fuel tank capacity	1 liter
Thermal efficiency (Design)	60%
Design fuel	Kerosene

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In India, the Bureau of Indian Standards (BIS) has set guidelines for testing the thermal efficiencies of all types of a cooking stove. For kerosene cooking stoves, the thermal efficiencies are determined according to the specifications provided by Indian Standards [3].

Following the guidelines, the thermal efficiency of the wick stove in the present work is estimated by conducting the water-boiling test and the procedure followed is briefly described below [2-5]. The fuel to be tested is to be filled with nearly ¾ of the capacity of the fuel tank. The aluminium vessel was selected as the fuel consumption test.

A thermometer (0-150) was used to evaluate the water temperature during experimentation. A stirrer made of aluminium has been made for stirring the water for uniform distribution of heat. An electronic balance (of least count 1 g) has been used for weight measurement of water and stove. The technical specifications of electronic balance are shown in TABLE 3.

The weight of the vessel with its lid and the weight of water used in the vessel was noted. The initial temperature of water (T1) was also noted. The weight of the stove along with fuel (W1) was noted. The stove was lighted and water was warmed up to 800C and stirred continuously for uniformity of temperature. When the final temperature of water (T2) reached 800C, the stove was put off. Again, the weight of the stove (W2) was recorded. The difference in the weight of the stove (W2-W1) gives the mass of fuel consumed for heating water by temperature (T2- T1). The thermal efficiency of the stove is expressed as follows:

$$\eta_{th} = \frac{(W_w \times C_w + W_{Al} \times C_{Al}) \times (T_2 - T_1)}{(W_1 - W_2) \times CV}$$

Where,

We = quantity of water in the vessel (kg),

W_{Al} = weight of the aluminium vessel (kg),

Cw = specific heat of water (kJ/kg-K),

C_{Al} = specific heat of aluminium vessel (kJ/kg-K),

T_1 = initial temperature of water (K),

T_2 = final temperature of water (K),

W_1 = weight of test stove before warming water (kg),

W_2 = weight of water after warming water to 80^0C (kg).

The experiment was repeated three times and an average of the three values was taken as the final reading. The same procedure was followed for all fuel blends.

TABLE 3: Specifications of Electronic Balance

Make	Aczet
Manufacture	Aczet pvt. Ltd Mumbai
Machine type	Electronic
Range	Maximum 15 kg; minimum 20g
Least count	1g
Model	CZ 15P

III. RESULTS AND DISCUSSIONS

The performance of the wick stove has been evaluated in terms of thermal efficiency and fuel consumption rate. Subsequent results as shown in bar graphs. Fig. 2 shows the effect of blending on the thermal efficiency of the wick stove. It is clear from the figure that the can be seen that maximum value of thermal efficiency was obtained with E05 i.e. blend containing 5% ethanol.

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The minimum value of thermal efficiency was 42.1% which was obtained with reference fuel operation. The effect of blending on the fuel consumption rate of the wick stove is shown in Fig. 3. It can be seen that the fuel consumption rate for E10 i.e., for the blend containing 10% ethanol while for reference fuel value was 4.01 x 10^{-5} kg/s.

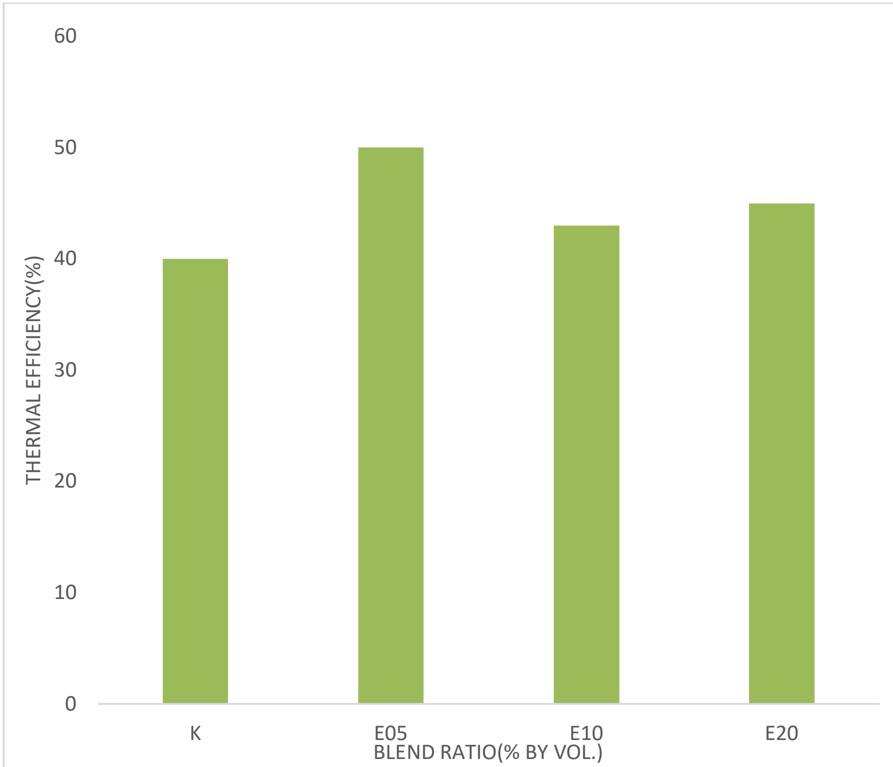

Figure 2: Thermal Efficiency Vs Blend Ratio

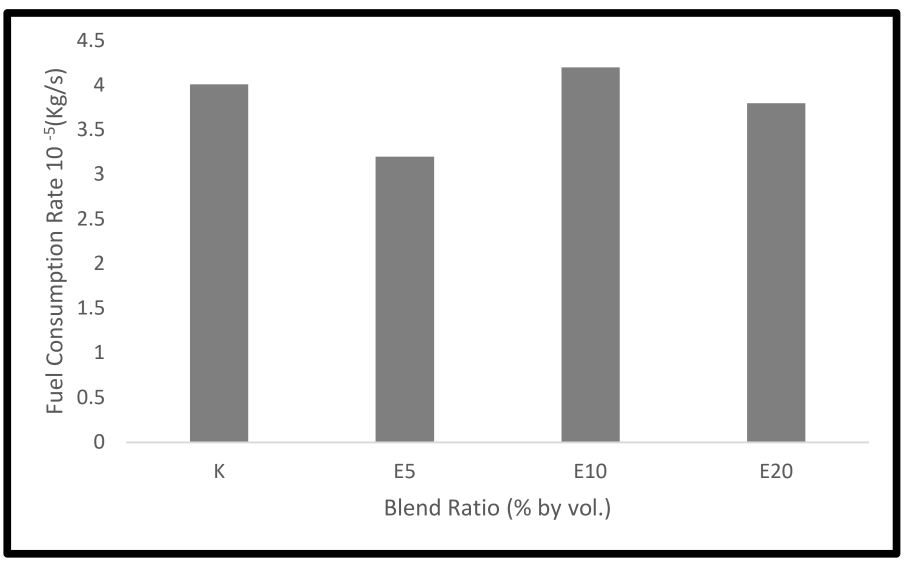

Figure 3: Fuel Consumption Rate Vs Blend Ratio

IV. CONCLUSION

The objective of the work was to study the effect of using various blends of ethanol and kerosene on the performance of a kerosene wick stove. The blends tested were 5%, 10%, 15%, and 20% ethanol in kerosene. The results show that blends of ethanol and kerosene can be successfully employed as used as an alternative fuel in wick-stove. The performance of the wick-stove operating on ethanol kerosene blends was evaluated in terms of thermal efficiency and fuel consumption rate. The values of thermal efficiency and fuel consumption rate for ethanol blended fuel were found to be comparable with reference fuel.

The maximum value of thermal efficiency was obtained with a blend containing 5% ethanol while the minimum value was obtained with reference fuel. The fuel consumption rate for the blend containing 10% ethanol was found to be maximum. It can be concluded that a capillary-fed multi-wick stove can be successfully operated with a kerosene- ethanol blend of up to 20% kerosene without any design modification and operational difficulty.

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