Ethanol-Kerosene Blends: Fuel Option for Kerosene Wick Stove

Mohd. Yunus Khan*, Faraz Ahmad Khan, Mirza Shariq Beg*****

* (Assistant Professor, Mechanical Engineering Section, University Polytechnic, Aligarh Muslim University, Aligarh)

** (B.Tech.(Mechanical Engineering), Z.H. College of Engineering and Technology, Aligarh Muslim University, Aligarh.)

*** (B.E.(Mechanical Engineering), Z.H. College of Engineering and Technology, Aligarh Muslim University, Aligarh.)

ABSTRACT

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

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

I. INTRODUCTION

Environmental pollution and fossil fuel depletion are matters of concern round the world. In order to solve tackle these problems, the search for alternative fuel has become significantly important. Alternative fuels selected should renewable, sustainable and eco-friendly. In India, kerosene is also used as a fuel in cooking stove. Kerosene stoves have replaced the traditional wood-based appliances that are unhealthy and inefficient. However, kerosene itself also contains impurities like sulphur, aromatics and hydrocarbons which cause pollution. On burning, it also produces 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 engine, for heating and lighting.

In India, it is also used as a fuel in wick stove or pressure to cook food. 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. Use of liquid fuels is preferable over 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 in cooking stove. These disadvantages are not found in ethanol and thus make it 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 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/cm^3 at 30°C)
Kerosene	43.5	0.820
Ethanol	26.9	0.785

The aim of this experimental investigation is to study the effect of using various blends of ethanol and kerosene on performance of kerosene wick stove. Pure kerosene was used as a reference fuel. These blends were prepared on 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 with an aim of obtaining comparative measures of thermal efficiency and fuel consumption rate. All experiments were carried out on unmodified stove.

II. EXPERIMENTAL METHODOLOGY

The experimental setup is shown in the Fig. 1. It consists of weighing balance, kerosene wick stove, a standard aluminium vessel, a stirrer and an alcoholic thermometer. The experimental setup consists of capillary fed wick stove. 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 the vice versa.

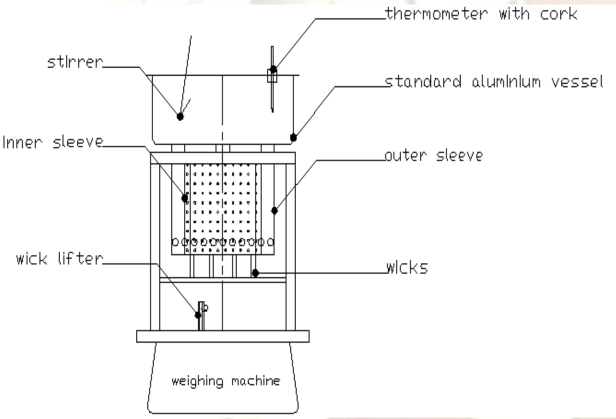

Fig. 1 Experimental setup

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

TABLE 2 Technical specification of test stove

Make	Fargo
Manufacture	MVS Enterprise, New Delhi
Stove Type	Capillary fed, multi wick
Weight	1 kg (when empty)
Fuel tank capacity	1 litre
Thermal efficiency (Design)	60%
Design fuel	Kerosene

In India, the Bureau of Indian Standards (BIS) has set guidelines for testing the thermal efficiencies of all types of cooking stove. For kerosene cooking stove, the thermal efficiencies are determined according to the specifications provided by Indian Standards [3]. Following the guidelines, thermal efficiency of 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 nearly ¾ of the capacity of the fuel tank. The aluminum 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 aluminum 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 vessel with its lid and the weight of water used in the vessel were noted. Initial temperature of water (T_1) was also noted. The weight of stove along with fuel (W_1) was noted. The stove was lighted and water was warmed up to 80^0C and stirred continuously for uniformity of temperature. When final temperature of water (T_2) has reached 80^0C, the stove was put off. Again, the weight of stove (W_2) was recorded. The difference in the weight of stove (W_2-W_1) gives the mass of fuel consumed for heating water by temperature (T_2-T_1). 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,
W_w = quantity of water in the vessel (kg),
W_{Al}= weight of the aluminium vessel (kg),
C_w= 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 average of the three values was taken as final reading. The same procedure was followed for all fuel blends.

TABLE 3 Specifications of electronic balance

Make	Gold Tech
Manufacture	Precision Electronic Instrument Co.,Delhi
Machine type	Electronic
Range	Maximum 10 kg; minimum 20g
Least count	1g
Model	G-TET

III. RESULTS AND DISCUSSIONS

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. 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 its value was 4.01 x 10^{-5} kg/s.

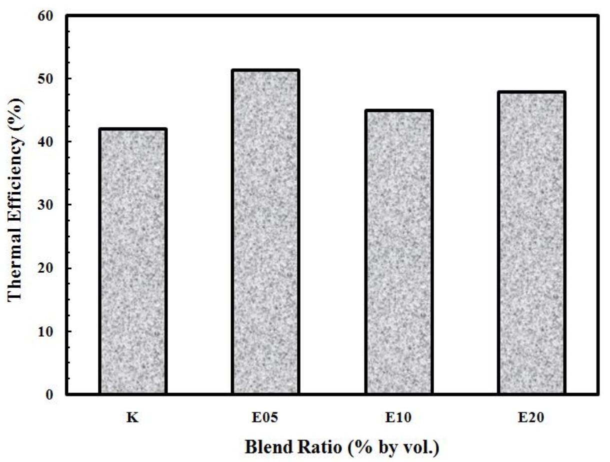

Fig. 2 Thermal efficiency Vs blend ratio

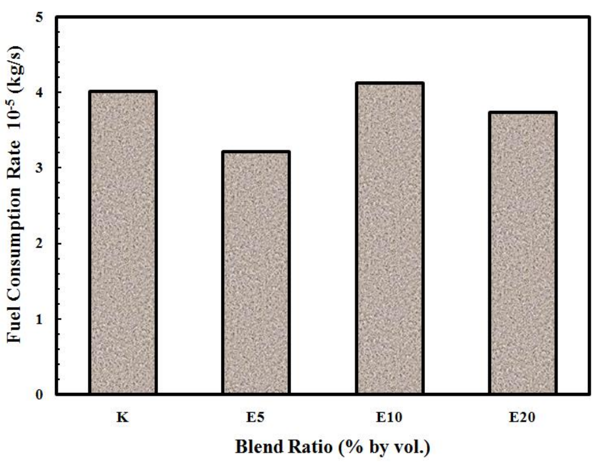

Fig. 3 Fuel consumption rate Vs Blend ratio

IV. CONCLUSIONS

The objective of work was to study the effect of using various blends of ethanol and kerosene on performance of 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 alternative fuel in wick-stove. 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 blend containing 5% ethanol while the minimum value was obtained with reference fuel. The fuel consumption rate for blend containing 10% ethanol was found to be maximum.

It can be concluded that capillary fed multi wick stove can be successfully operated with kerosene- ethanol blend up to 20% kerosene without any design modification and operational difficulty.

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