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Studies on Performance of Metallic wick using Kerosene and Biodiesel

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Abstracts

Cotton wicks are normally used for heating stove and lightening lamps. It is felt that frequent changing of cotton wicks can be avoided by developing metallic wicks using powder metallurgy techniques. Conventional stove cannot accommodate these metallic wicks. To accommodate them the wick carrier is slightly modified. Existing lifting mechanism in stove is modified for the sake of simplicity. The wick carrier tubes are slightly enlarged and shortened. According to literature survey much work is not carried out in this direction. Hence the present work is taken up to study the efficiency of metallic wick stove using kerosene and compare it with conventional cotton wick stove.

Fabricated Metallic wicks are fitted in the fabricated wick carrier. Further the performance characteristics using metallic wick such as fuel consumption, fuel tank temperature, flame height, capillary action are studied. The efficiency of metallic wick is compared withs conventional stove and the results are compared.

An attempt has been made to explore the suitability of seed oil (bio fuel) as a fuel in substituting Kerosene. This oil has a very high viscosity and as a result, cannot flow through capillary in a lamp and hence, requires viscosity reduction by a transesterification process to convert it into biodiesel. Hence, the project work is undertaken to develop metallic wick stove similar that of stove commercially used, fuelled by 100% biodiesel for its heating and its comparative performance with respect to a standard kerosene lamp.

Keywords: Metallic wick.

Introduction

Wick can be considered as a capillary –porous metal. It sucks fuel at one end and delivers to the other end like a capillary pump where it is utilized. Usually in kerosene stoves cotton wicks are used which need to be replaced frequently. To avoid this, non- consumable metallic wicks are developed. The wicks are developed from bronze powder. Bronze powder is selected due to its high corrosion resistance and it ensures porous structure undisturbed. Compared with paper, glass, ceramics, metals and other materials, porous bronzes exhibit a number of virtues. They are lighter in weight, corrosion resistance, work in wide range of temperatures and possess high electrical and thermal conductivity besides enough mechanical strength.

Today it is very essential to use alternative fuel because of energy scarcity, environmental concerns and socio-economic reasons. Over the last few years biodiesel has gained importance as an alternative fuel for diesel engines. Manufacturing biodiesel from vegetable oil is relatively easy and possesses many environmental benefits. The use of vegetable oils as frying oils produces significant amounts of used oils which may present a disposal problem. Their use for biodiesel production has the advantage of their low price. Used vegetable oil is described as a 'renewable fuel' as it does not add any extra carbon dioxide gas to the atmosphere, as opposed to fossil fuels and cause changes in the atmosphere. From the point of view of chemical reaction, vegetable oil from plant sources is the best starting material to produce biodiesel because the conversion of pure triglyceride to fatty acid methyl ester is high and the reaction time is relatively short. The most common way to produce biodiesel is by transesterification. This means chemical reaction involving vegetable oil and an alcohol to yield fatty acid alky esters (ie, biodiesel and glycerol) In the transesterification work, sunflower seed oil, methanol and KOH in various concentration are refluxed together in a 500 ml glass reactor equipped with a glass anchor shaped mechanical stirrer, a water condenser and funnel. After the complete conversion of the vegetable oil the reaction is stopped and the mixture is allowed to stand for phase separation: the ester mixture is formed in the upper layer and glycerin in the lower layer.

And then finally compare the performance of metallic wick such as fuel consumption, rate of fuel rise, flame height using kerosene and biodiesel.

Process details

A. Parameters:
Raw material: sun flower oil
Pre heating temperature: 60ºC
Pressure: atmosphere

B. Biodiesel production
The process depends upon the type of oil employed and whether it is fresh oil or used oils from the catering industry. In the case of latter, a titration process takes place and the result of which determines the proportions of methanol to potassium hydroxide used. The following are the steps required for the production of bio diesel:

C. Titration
This process is carried out to determine the amount of potassium hydroxide required. It is the most crucial and the most important stage of Bio-Diesel manufacturing. Titration method is for determining how much catalyst needed to neutralize the fatty acids in the used vegetable oil

- Dissolve 1 gram of KOH in 1 liter of distilled water.
- Dissolve 1 liter of waste vegetable oil into 10 ml isopropyl alcohol
- With an eyedropper, set the pH by 8-9. By adding one milliliter NaOH at a time, ph level is raised.
- Record the quantity of KOH solution added until the color of the oil changes to pink and holds it for at least 5 seconds (This represents a pH of between 8 and 9).

D. Titration to Determine the Excess Catalyst
- Burette solution: KOH solution – 1000ppm
- Pipette solution: 1 ml of used vegetable oil
- Solvent : 10 ml isopropyl alcohol
- Indicator : phenolphthalein
- End point : appearance of pink color

E. Preparation of Potassium Methoxide
- Carefully pour the KOH solution into 100 ml methanol
- Agitate the mixture until the KOH is completely dissolved in the methanol.

F. Heating and Mixing
The potassium methoxide solution prepared is mixed with oil. The residue is heated in between 55ºC to 65ºC after which it is mixed well using a stirrer at required speed.
- Continue mixing the contents.
- Carefully pour the potassium methoxide and shake vigorously for 15 minutes.

G. Settling and Separation
After mixing the liquid, it is allowed to cool down. After the cooling process, the bio fuel is found floating on the top while the heavier glycerin is seen at the bottom. The glycerin is easily separated by allowing it to drain out from the bottom. In this way pure Bio diesel is prepared.

- Allow the glycerin to settle
- Settle the mixture overnight.
- The successful chemical reaction between the oil into several layers.
- The top layer will be biodiesel, chemically called an ester, the next layer may contain soap, and the bottom layer will be glycerin

H. Washing
Biodiesel and glycerin will separate due to density difference. Glycerin and unrelated catalyst will sink to the bottom and can be easily drained. After separation of biodiesel it must be washed with hot water to remove unreacted methanol and potassium hydroxide.
Filtration
In this process, the waste vegetable oil is filtered to remove all the food particles. This process generally involves warming up the liquid a little. After warming, it is filtered with the use of a cotton cloth.

J. Removing Water
All the water contained in the residual gangue is removed which makes the reaction faster. The water is easily removed by boiling the liquid 50ºC for some time.

K. Fuel Properties Analysis
Fuel properties analysis was carried out according to ASTM Biodiesel Standards. Fuel characteristics of biodiesel which were tested include dynamic viscosity at 40ºC (eta), kinematic viscosity at 40ºC (ny), density at 40ºC (Rho), flash point (ºC), cloud point (ºC), specific gravity at 20ºC (Kg/1), carbon residue, acid value and Calorific value.

L. Capillary Action Test
Metallic wicks are coated with chalk powder throughout and marks are made at regular intervals of 5mm. Length of the wicks used are 70mm during the test, specimen is held in the stand by fixing it at the top end. A beaker, which contains kerosene, is raised to required depth of immersion and held at that position. At the same instant,

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stopwatch is started. The liquid ascends by capillary action and wets the specimen. This wetting is clearly observed by the color of the specimen. The same procedure is repeated for different depths of immersion.

M. Flame Height Test
The wick is held in position using a wick holder. The wick holder has a retaining screw using, which the length of tip exposure may be adjusted. A scale is marked on the bottle to monitor the flame without parallax. After lighting the flame height is recorded for different fuels levels, for different tip exposures. Graphs are plotted between fuel levels, tip exposures versus flame height.

N. Water Pot Temperature Test
To know the output of the fabricated metallic wick stove a sample test has been conducted. 1000ml of water is taken in an aluminum container and kept over the stove. The time required reaching boiling point of water both metallic wick stove and conventional wick stove are studied and compared.

O. Fuel Tank Temperature Test
The temperature produced in the fuel tank during boiling of 1000ml of water with respect to time is noted. The same test is conducted for metallic wick stove using kerosene and both results are compared.

P. Fuel Consumption Test
The fuel consumed during boiling of 1000ml of water is measured for metallic wick using kerosene and compared with conventional cotton wick.

Q. Fabrication of wick holder and lifting Mechanism
To accommodate metallic wicks the locally available wick carrier is modified. The wick carrier tubes are enlarged and shortened. The existing stove mechanism is not suitable for metallic wicks. Cotton wicks are flexible and any misalignment in lifting and lowering mechanism it can accommodate. But metallic wicks are rigid and they cannot bear any misalignment in lifting mechanism. Uniform rising and lowering is made by incorporating lever mechanism.
Specifications of metallic wick stove
Fuel tank
Diameter = 25.5 cm
Height = 6.5 cm
Wick diameter = 1 cm
Wick carrier tube diameter = 1.2 cm
Maximum lift = 10 cm
Number of wicks = 10

Results & discussions

i. Biodiesel Production Test
Following observations are made during biodiesel diesel production process. The results are as shown in table.1

Table.1. Properties of biodiesel

Properties	**Values**
Sp. gravity	0.915
Flash point	250°C
Fire point	296°C
Cloud point	11°C
Pour point	-6°C
Viscosity (at 35°C)	59.8 CentiStoke (0.598m2/sec)
Calorific value (HHV)	40 MJ/Kg (approx)

ii. Capillary Action Test
Capillary rise versus time is an exponential curve indicating that every additional millimeter rise of the liquid takes more time compared to the previous rise and there-by indicating that level of fuel does play a role, as shown in figure.1.

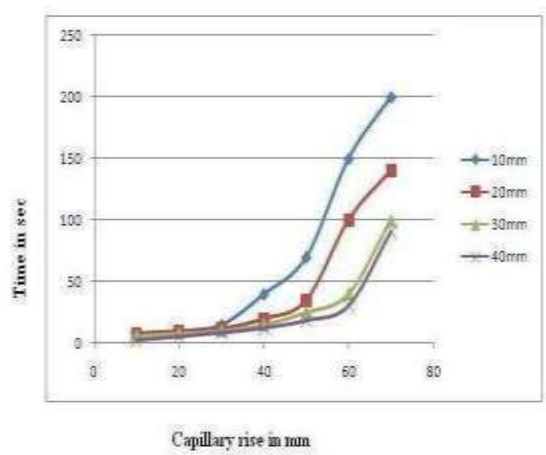

Fig. 1 Variation of time with capillary rise for different depth of immersion

iii. Flame Height Test
From the test, it is observed that flame is sooty with higher fuel level and large tip exposure as given in figure.2.

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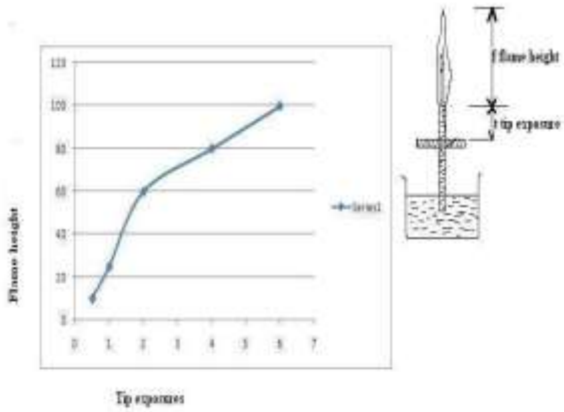

Fig. 2 Variation of flame height for different tip exposure (fuel level=50mm)

The relation between fuel level and flame height is given in figure.3. It is found that increase in fuel level increases flame height.

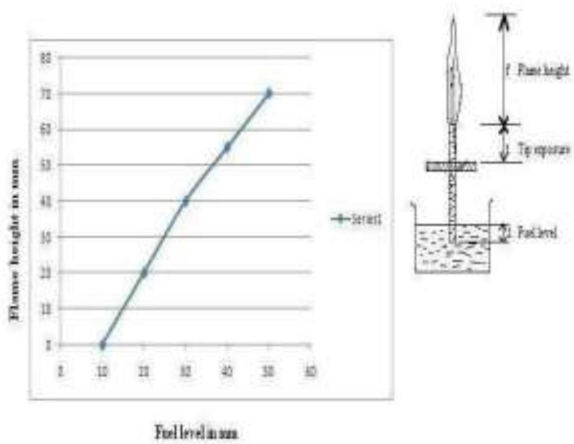

Fig.3 Effect of flame height on fuel level (tip exposure-5mm)

The relation between various fuels such as kerosene, biodiesel, biodiesel blends with flame height is given in figure.4. It is observed that kerosene given better fuels. This may be due to higher calorific value of kerosene.

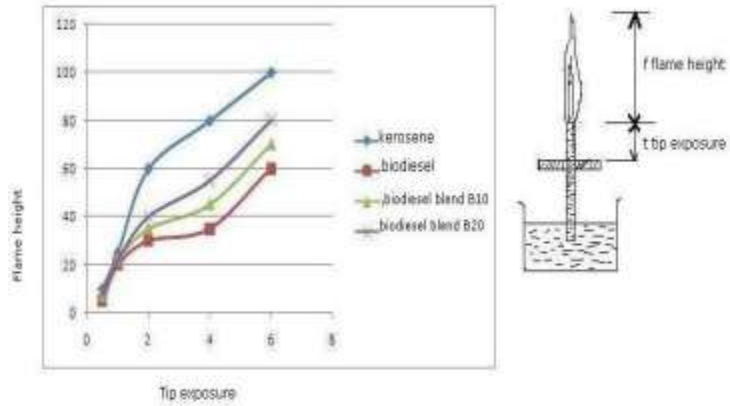

Fig.4 Effect of flame height with different fuels for different tip eposure

iv. Water Pot Temperature test
The temperature increase is rapid in case of metallic wicks. Graph plotted between temperature of water and time for both conventional and metallic wicks is shown in the figure.5

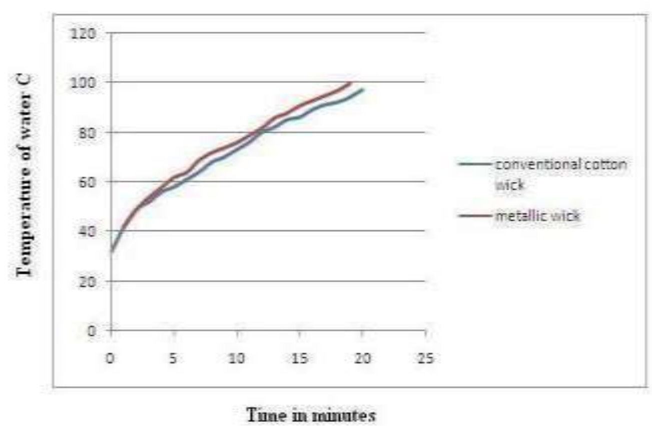

Fig.5 variation of temperature of water with time

v. Fuel Tank Temperature Test
Due to use of metallic wicks, by conduction the fuel tank gets heated and extend if fuel heating is observed. It is noted that for 6 hours heating the fuel gets heated to 80ºC which is less than the flash point.

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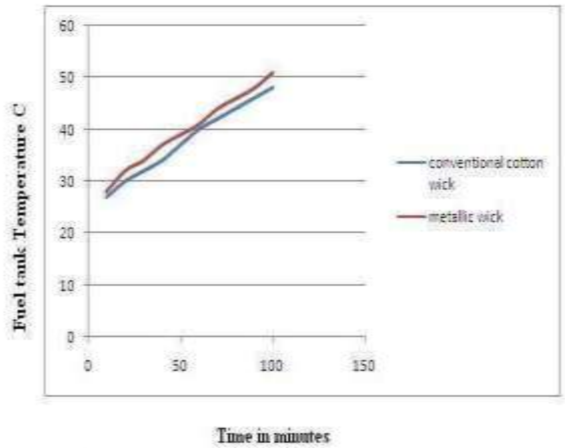

Fig.6 variation of fuel tank temperature with time

vi. Fuel Consumption

Fuel consumed for boiling one liter of water, for one hour in aluminum container for both metallic wicks and cotton wicks are given below. Kerosene used initially is 2 liter.

Fuel consumed for cotton wick = 440 ml
Fuel consumed for metallic wick = 370 ml

Utilization efficiency

The following data is used to calculate the utilization efficiency. This data is obtained by conducting sample experiments on metallic wick stove such as water pot temperature rise test, fuel tank temperature test and fuel consumption test.

Data

Conventional wick

M_k = mass of kerosene initially
= 2lt
= 1.6464Kg

ρ of kerosene = 823.2Kg/m^3

Mass of kerosene consumed = 440 ml
= 0.36220 Kg

C.V = calorific value of kerosene
= 8359KJ/Kg

Mw = mass of water taken initially
=1liter

Mass of water evaporated during one hour operation = 0.75liter

L_w = Latent heat of vaporization of water
= 2257KJ/Kg

Specific heat of kerosene, Cp = $46.4*10^{-6}$KJ/Kg

ΔT_k = Temperature rise of kerosene
= (50-30)
=20ºC

ΔT= Temperature rise of water
= (100-32)
=68ºC

Metallic wick:

Mass of kerosene consumed= 370ml
=0.30458Kg

Mass of water evaporated = 0.80liter

Calculation of utilization efficiency

Utilization Efficiency
= Heat utilized for water boiling* 100 /Heat supplied

Conventional wick:

Heat supplied =M_k Consumed (Kg)*C.V of Kerosene
= 0.36220*8359
=3027.6KJ/Kg

Heat utilized = [M_w *Cp of water*ΔT]+ [M_w evaporated*L_w] +[M_k*Cp of Kerosene*ΔT_k]

=[1*4.186*68]+[0.75*2257]+[1.6464*46.4*10^{-6}*20]
= 284.64 +1692.75+0.00152
= 1977.39KJ/Kg

Utilization efficiency = 1977.39*100/3027.6
= 65.3%

Metallic wick:

Heat supplied = Mk*C.V of Kerosene
= 0.30458*8359
= 2545.98KJ/Kg

Heat utilized =[M_w*Cp of water *ΔT]+ [M_w evaporated*L_w] + [M_k*Cp of kerosene *ΔT_k]

=[1*4.186*68]+[.80*2257]+[1.6464*46.4*10^{-6}*20]
= [284.64] + [1805.6] + [0.00152]
= 2090.24KJ/Kg

Utilization efficiency = (2090.24)*100/ 2545.98
= 82.09%

Conclusions and scope for future work

From the observations made during the study of metallic wick stove the following conclusions are drawn

1. Metallic wick is a viable one like cotton wick in capillary action and is a permanent one.
2. By selecting bronze (90%Cu+105Sn), it withstand in kerosene bath for a long period without corrosion.

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3. The efficiency of metallic wick is greater than that of conventional cotton wick.
4. Biodiesel is also a viable fuel like kerosene for lighting and heating process.

Scope for future work

Cooling system can be designed for stove to reduce the fuel tank temperature. Use of metallic wicks for industrial heating and in railways for lighting can be extended.

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