Performance Evaluation of Cooking Stove Working on Spent Cooking Oil

Gaurav Jambhulkar, Vibhor Nitnaware, Manisha Pal, Neha Fuke, Purva Khandelwal, Pallavi Sonule, Sneha Narnawre, V. P. Katekar

Abstract- This paper deals with the use of spent cooking as a fuel in kerosene stove In order to avoid the reuse of spent cooking oil for cooking which has adverse effects on the health of human being, corrective steps are needed to be taken. With an approach of alternative fuel for kerosene pressurized cooking stove, blends of kerosene and spent soya bean cooking oil of various proportions have been prepared. These samples were tested one by one in an existing kerosene pressurized cooking stove at various pressures. From the study, it has been found that at 1.5 bar pressure, efficiency of 50% proportion of spent soya bean oil with 50% proportion of kerosene is better than pure kerosene.

Keywords: kerosene stove, spent soya bean oil, magnetization, efficiency, calorific value.

I. INTRODUCTION

A. Purpose of study

1) Use of kerosene and pressurized kerosene cooking stove in India

Kerosene is one of straight-run fractions resulting from distillation of crude oil between 205°C and 260°C, having flash point of 38–72°C, boiling point of 150°C to 300°C and auto-ignition temperature of 220°C. Main components of kerosene are paraffin, cycloalkanes (naphtha) and aromatic compounds, where paraffin is of highest composition. Ultimate analysis of composition of kerosene are 84.3% wt of Carbon, 14.2% wt of Hydrogen, and remaining are sulphur, nitrogen etc. Combustion of 1 gram of kerosene results in about 3 grams of carbon dioxide having volume of 1.2-1.5m3/liter. Incomplete combustion gives lower flame temperature and heating rate. Approximately 72% of the population of India lives in rural areas.

Manuscript Received on February 2015.

Gaurav Jambhulkar, Department of Mechanical Engineering, S.B .Jain Institute of Technology, Management and Research, Katol Road, Nagpur, India.

Vibhor Nitnaware, Department of Mechanical Engineering, S.B .Jain Institute of Technology, Management and Research, Katol Road, Nagpur, India.

Manisha Pal, Department of Mechanical Engineering, S.B .Jain Institute of Technology, Management and Research, Katol Road, Nagpur, India.

Neha Fuke, Department of Mechanical Engineering, S.B .Jain Institute of Technology, Management and Research, Katol Road, Nagpur, India.

Purva Khandelwal, Department of Mechanical Engineering, S.B .Jain Institute of Technology, Management and Research, Katol Road, Nagpur, India.

Pallavi Sonule, Department of Mechanical Engineering, S.B .Jain Institute of Technology, Management and Research, Katol Road, Nagpur, India.

Sneha Narnawre, Department of Mechanical Engineering, S.B .Jain Institute of Technology, Management and Research, Katol Road, Nagpur, India.

V. P. Katekar, Department of Mechanical Engineering, S.B .Jain Institute of Technology, Management and Research, Katol Road, Nagpur, India.

Large population of India still doesn't have access to electricity and gas and is solely dependent on kerosene oil and continues on kerosene as fuel for cooking, heating and lighting. Electrified households in rural areas also use kerosene as a backup fuel due to the interruptive and poor electricity supply. It is widely used in power jet engines, for the manufacture of insecticides/herbicides/fungicides to control pest, weeds and fungi. It has been estimated that nearly 855 million people use 9.101 MT (2011-12) of kerosene for cooking. Kerosene has been promoted as an alternative fuel to biomass in rural areas. Thermal efficiency of kerosene stove is 20–40% depending on stove and cooking equipment design.

India's fossil fuel subsidies- a timeline

The majority of India's kerosene consumption is of approximately 12 million KL is heavily subsidized. Many of the rural and urban Indian residents also receive their kerosene through Public Distribution system. The subsidy was initially established as a distribution scheme during fuel shortages in World War II.

2) Problems

Kerosene contains impurities such as sulphur, aromatics and hydrocarbons. On burning, it produces very unpleasant odour. The smoke emissions cause various respiratory disorders. A steep increase in prices and withdrawal of subsidy has results in its diminishing supplies. Utmost 60 per cent of subsidized kerosene reaches the intended beneficiaries (Our Economy Bureau, 2005). The remainder is diverted to the black market. The diversion of kerosene is a business for corrupt fuel distributors.

Bad effects of spent cooking oil if reused as cooking oil

Oil has become an everyday use. Using or eating oil is not harmful, but using it more than required may be harmful to our health. Eating oil of a worst quality unknowingly can cause serious diseases such as throat infection, digestive problem, hyper acidity that is burning sensation, etc.

Fig. 1.1 Uses of Oil

If spent cooking oil is reused at a very later stage, it increases the thickness of oil and its fat increases. Due to the increase in thickness or viscosity of oil, harmful bacteria and

*Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.*

free radicals get accumulated in oil which leads to various diseases.

Fig. 1.2 Used Oil

Diseases

Arteriosclerosis:- The word 'Arteriosclerosis' itself describes artery related disease. It is due to consumption of spent oil containing many harmful things along with extra fat. This fat contains cholesterol that gets deposited inside the arteries which results in blockage of arteries causing irregular flow of blood and further leads to heart diseases.

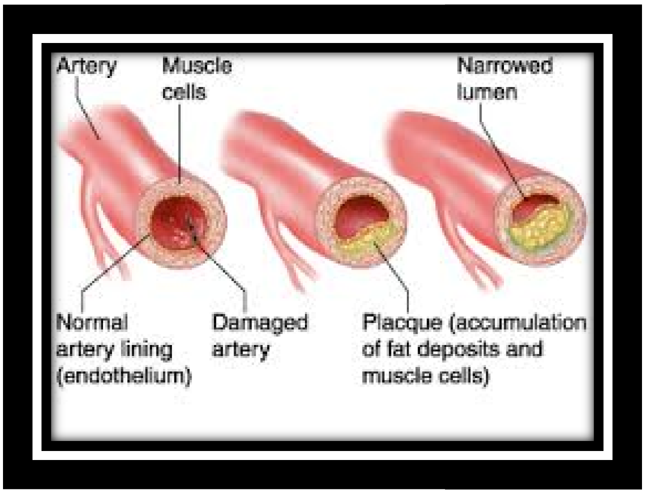


Fig. 1.3 Arteriosclerosis

High blood pressure:- In the previous type of disease, there occurs a deposition of cholesterol inside the arteries causing irregular flow of blood. This also results in High blood pressure which tries to flow inside the arteries, that ultimately affects the functioning of heart.

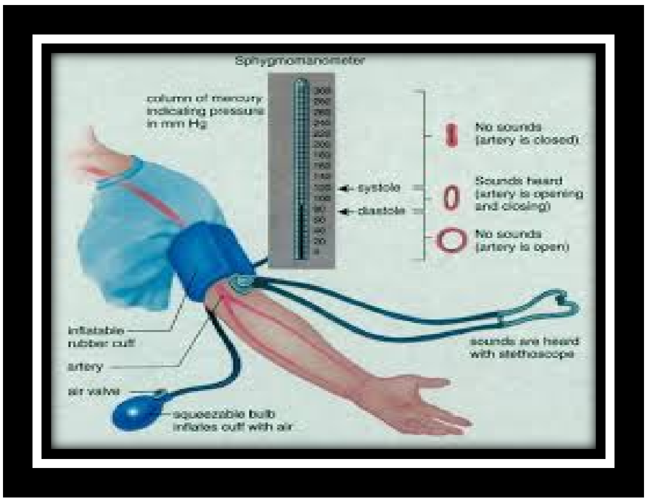


Fig. 1.4 High Blood Pressure

B. Scope of work

1) Using used cooking oil as kerosene pressurized cooking stove fuel and designing of stove.

As it is found that the consumption of the spent edible oil causes many health hazards, therefore there is a need to develop a stove using used cooking oil as a fuel. The Renewable Energy Development Institute (REDI), Germany [4], has been working for more than 20 years to develop a simple cooking stove using different fuels such as kerosene, diesel, vegetable oil, etc. The fuel tank is kept at a higher level to facilitate gravity flow. The Institute of Agricultural Engineering in the Tropic and Subtropics of Hohenheim University, Germany [7], has been experimenting on a vegetable oil cooking stove. The fuel passes through the flow regulator valve, vaporizers and a spray nozzle. The combustion space is covered with a flame holder having many holes to supply sufficient air. The fuel tank consists of two parts. Initially the stove is ignited with kerosene and after 2–3 min of operation, the kerosene valve is closed and vegetable oil is injected. Leyte State University, Germany, has developed a plant oil stove for Bosch and Siemens for marketing in Philippines. They have achieved efficiencies up to 40–50%. Other universities and institutions that have also contributed to the development of vegetable oil stoves are GTZ Probec Protos Stove Tests Tanzania, Working Group of Development Techniques (WOT), Enschede, and Netherland.nAll these stoves call for modification and fabrication of fuel tanks, burners, pressure pump and feed pipe lines in the standard stove. The standard stove consists of:-

(a) fuel tank,

(b) Hand pressure pump developing 1.6-1.8bar pressure in the fuel tank,

(c) Burner with suitable preheating and fuel injection arrangement and

(d) A manual control device and a pin for mass flow rate of fuel.

Due to the pressure created in the fuel tank, the fuel flows through the feed line. The flow of the fuel is regulated with a valve provided in the oil line. Initially, the fuel is heated in the burner plate to vaporize and raise the temperature above fire point. The hot fuel mixes with the air and gives out a yellow-blue flame. The efficiency of the combustion is a function of:-

(a) Temperature of oil,

(b) Vapor to liquid ratio and

(c) Mixing efficiency of fuel with air.

Equipments that need to be incorporated in modified kerosene pressurized cooking stove: - modified commercially available burner (copper plate brazed to the fuel injection), spray nozzle with modified exit angle, location of the vessel.

To compute the thermal efficiency, experiments were carried out to determine the energy consumed for:

(a) Sensible heat to heat the vessel and

(b) Heat supplied to a known quantity of substance say water at given temperature and at atmospheric pressure. The experiment is needed to be repeated three times for obtaining accuracy.

$$\text{thermal efficiency} = \frac{\text{heat utilized}}{\text{heat supplied}}$$

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

2) magnetisation of fuel **:-**

For many years, researchers tried to design a combustion system causing low air pollution through complete combustion of hydrocarbons. Various techniques, such as air-fuel mixing, ignition, temperature controlling combustion chamber, catalyst, etc are not able to completely solve the problems yet. Low efficiency of combustion heat, unburned fuel and air pollution (like CO, NOx,SOx) are still problems now. Enhancement of hydrogen reactivity is one of important ways in order to reach the complete combustion.There is a novel technique called 'Magnetization'[2]. Magnetization of hydrocarbon fuel which is diamagnetic, breaks clusters of hydrocarbon molecules and changes the electron spin direction of para state (low energetic) into orthostate (high energetic). They are normalized , independent and distant from each other, having large surface available for binding (attraction) with more oxygen (better oxidation). Finally, complete combustion can be achieved. The other advantages are:-

- Increase in the combustion efficiency.
- Magnetization technique is relatively cheap and not dangerous comparing to existing additive fuel.

The declustering, polarization and reactivity phenomena due to magnetizationof hydrocarbon are still in controversy which are explained by limited scientific publications. Before combustion, the kerosene will be magnetized by magnetic field. The distance of magnet from burner has effect on thermal efficiency. Fig.1.6 shows the working burner assembly. Kerosene with the aid of air pressure, forced from the fuel tank passes to the burner through main fuel supply pipe and rises through the rising tube (A) further through the ascending pipe (B) to the preheated burner head (C), where the fuel is heated and vaporized. The gas produced from the kerosene flows further on, and through a narrow opening, the jet mixes with the air outside where it burns with a blue, smokeless flame, turning a small "air screw" (usually located in the filler cap) will release pressure from the tank and make the flame smaller. In the modified pressurized kerosene stove, a copper coil of 2 turns is wound around the burner. The height of the coil is just below the cup of the burner, such that the flame doesn't get into the direct contact of the coil. Both the ends of the coil are brazed to the main fuel supply pipe of the stove, and the main fuel supply pipe is blocked by means of cutting between the two coil ends. This arrangement is made in view so that the fuel only passes through the coil.

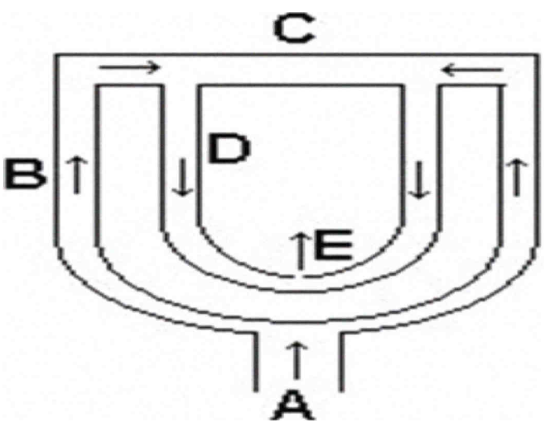


Fig. 1.6 Illustration of Burner Assembly

Fig. 1.7 Preheating Burner Assembly

3) Using blends of kerosene and spent cooking oil as a fuel in the kerosene pressurized cooking stove:

Blends of various proportions that are taken into account:-

1)25% of spent cooking oil with 75% kerosene oil

2**)** 50% of spent cooking oil with 50% kerosene oil

3) 75% spent cooking oil with 25% kerosene oil.

II. METHODOLOGY

Initially the experimentation is done on regular commercially designed stove which is available in the market to check its performance. Experimentation is done by using first pure kerosene then further we have used various blends of kerosene with spent Soya bean oil as a fuel in the stove.

TABLE I

SOME PHYSICAL PROPERTIES OF TYPICAL SOYA BEAN OIL

Density at 20°C	0.9165 to 0.9261
Melting Point	0.6°C
Specific Heat Capacity	448 cal/g°C
Pour Point	-12 to -16°C
Cloud Point	-9 °C
Heat of Combustion	9388 cal/g
Heat Transfer Coefficient	269.7 watts/K-m2at 180°C
Viscosity at 20°C	58.5 to 62.5 cP
Vapor pressure	1 μ at 254°C
Smoke point	245°C
Flash point	324°C
Fire point	360°C
Heat of vaporization	44200cal/mol
Surface Tension at 30°C	27.6 dyne/cm
Refractive Index at 20°C	1.4733
Dry electrical resistivity at 24°C	23.7 Tohm-cm

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

Fig. 3.1: Existing Stove Design

The concentration of the oil with kerosene is as follows:

1. 100% kerosene.
2. 75% kerosene and 25% spent Soya bean oil.
3. 50% kerosene and 50% spent Soya bean oil.
4. 25% kerosene and 75% spent Soya bean oil.

The stove tank's capacity is 1.5 kg. The experimentation is carried out at various pressures. The pressures are:

1) 1 bar,
2) 1.5 bar
3) 2 bar

To carry out the experimentation at exact pressure stated above, we fitted a pressure gauge to the tank, so that exact readings at various pressures can be taken.

Fig. 3.2: Pressure Gauge

The procedure is as follows:

1. First fill the tank with pure kerosene (1 kg).
2. Pumping is to be done to reach the desired pressure of 1 bar.
3. The stove burner is ignited by external source of fire e.g. - matchstick.
4. A vessel containing 2 kg water is kept at the top ring of the stove.
5. Now exactly at an interval of 5 min, readings are noted down, which include the amount of fuel burnt, mass of water present and temperature of water.
6. Similar process is carried out until water doesn't reach its boiling or saturation point (equivalent to 100°C).
7. Blends of kerosene and spent soya bean oil prepared by uniformly mixing it with a hand operated electric blender till we get a homogeneous blend.
8. Now emptying the tank which was earlier filled with kerosene, and filling it with various blends of kerosene.
9. Repeating the above procedure for other blends, finding out the efficiency of stove for each reading.
10. Repeating the above procedure for other blends, finding out the efficiency of stove for each reading.

In order to determine lower calorific values of vari ous fuel blends, we gave the sample of various blends in the testing lab whose report is shown in the following page.

A. Observations and calculations

During the above experimentation, some observations and calculations have been taken to calculate the efficiency of the stove. The calculations after taking the results are shown in this chapter.

The efficiency is given by the formula:

$$\eta = \frac{m_w \times c_{p_w} \times (T_2 - T_1) + m_v \times c_{p_v} \times (T_2 - T_1)}{m_f \times cv}$$

.................*Equation no.1*

Where,
mw =Mass of water in Kg
cpw = Specific heat of water= 4180 KJ/Kg
T1 =Initial temperature of water in °C
T2 = Final temperature of water in °C
mv = Mass of vessel ; *mv* = 0.39 Kg
cpv = Specific heat of vessel; *cpv*= 500 KJ/Kg
mf = Mass of fuel consumed in Kg
cv = calorific value of fuel(KJ/Kg)

Data analysis has been done after the above experimentation.

- Heat gained by water ;

$$A = m_w \times c_{p_w} \times (T_2 - T_1),$$

- Heat gained by the vessel ;

$$B = m_v \times c_{p_v} \times (T_2 - T_1)$$

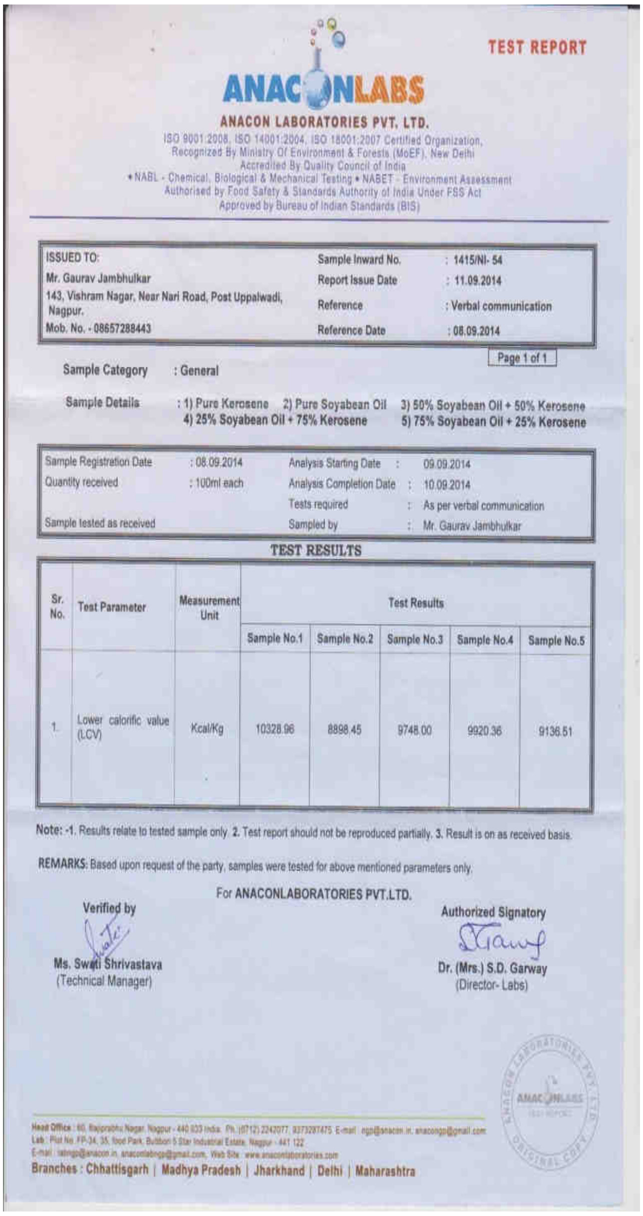
- Heat supplied

$$C = m_f \times cv$$

Efficiency

$$\therefore \quad \eta = \frac{A + B}{C}$$

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.



TEST REPORT

ANACONLABS

ANACON LABORATORIES PVT. LTD.

ISO 9001:2008, ISO 14001:2004, ISO 18001:2007 Certified Organization,
Recognized By Ministry Of Environment & Forests (MoEF), New Delhi
Accredited By Quality Council of India
• NABL - Chemical, Biological & Mechanical Testing • NABET - Environment Assessment
Authorised by Food Safety & Standards Authority of India Under FSS Act
Approved by Bureau of Indian Standards (BIS)

ISSUED TO: Mr. Gaurav Jambhulkar, 143, Vishram Nagar, Near Nari Road, Post Uppalwadi, Nagpur. Mob. No. - 08657288443	Sample Inward No. : 1415/NI- 54 Report Issue Date : 11.09.2014 Reference : Verbal communication Reference Date : 08.09.2014

Page 1 of 1

Sample Category : General

Sample Details : 1) Pure Kerosene 2) Pure Soyabean Oil 3) 50% Soyabean Oil + 50% Kerosene 4) 25% Soyabean Oil + 75% Kerosene 5) 75% Soyabean Oil + 25% Kerosene

Sample Registration Date	: 08.09.2014	Analysis Starting Date	: 09.09.2014
Quantity received	: 100ml each	Analysis Completion Date	: 10.09.2014
		Tests required	: As per verbal communication
Sample tested as received		Sampled by	: Mr. Gaurav Jambhulkar

TEST RESULTS

Sr. No.	Test Parameter	Measurement Unit	Test Results				
			Sample No.1	Sample No.2	Sample No.3	Sample No.4	Sample No.5
1.	Lower calorific value (LCV)	Kcal/Kg	10328.96	8898.45	9748.00	9920.36	9136.51

Note: -1. Results relate to tested sample only. 2. Test report should not be reproduced partially. 3. Result is on as received basis.

REMARKS: Based upon request of the party, samples were tested for above mentioned parameters only.

For ANACONLABORATORIES PVT.LTD.

Verified by
Ms. Swati Shrivastava
(Technical Manager)

Authorized Signatory
Dr. (Mrs.) S.D. Garway
(Director- Labs)

Lab : Plot No. FP-34, 35, Food Park, Butibori 5 Star Industrial Estate, Nagpur - 441 122
Branches : Chhattisgarh | Madhya Pradesh | Jharkhand | Delhi | Maharashtra

Fuel used: Kerosene (100%):-
Date: 22/08/2014, Time: 4:05 pm
At pressure= 1.5 bar; Time interval= 5min

TABLE I

EFFICIENCY OF PURE KEROSENE

Mass of water	1.986
Temperature difference	20.33
Consumption of fuel	0.014
Calorific value of fuel	43234961
A	169290
B	3965
C	605289
Efficiency	0.2702

Fuel used: 50% kerosene and 50% spent soya bean oil
Date: 07/09/2014, Time: 5:30 pm
At pressure= 1.5 bar; Time interval= 5min

TABLE II

EFFICIENCY OF 50% KEROSENE AND 50% SPENT SOYA BEAN OIL

Mass of water	1.981
Temperature difference	13.6
Consumption of fuel	0.0096
Calorific value of fuel	40803178
A	113047
B	2652
C	391710
Efficiency	0.3844

III. RESULTS AND DICUSSION

A. Variation of efficiency with pressure

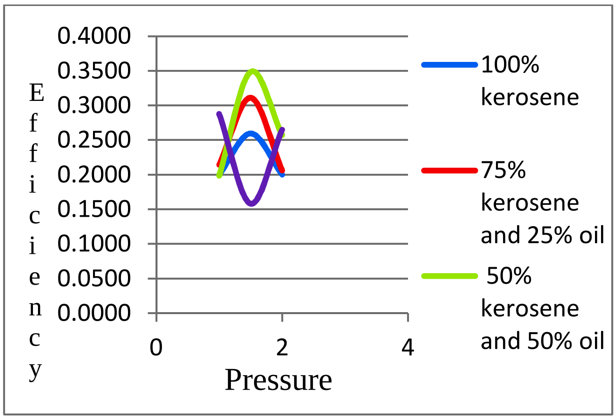


Fig. 4.1: Variation of efficiency with pressure.

As depicted in fig. 4.1, maximum efficiency is get in 50% spent soya bean oil with 50% kerosene blend at 1.5 bar pressure followed by that of 75% kerosene with 25% spent soya bean oil. Then comparatively lower efficiency is observed in the case of 100% kerosene. The lowest efficiency is seen in case of 25% kerosene with 75% spent soya bean oil.

B. Consumption of fuel

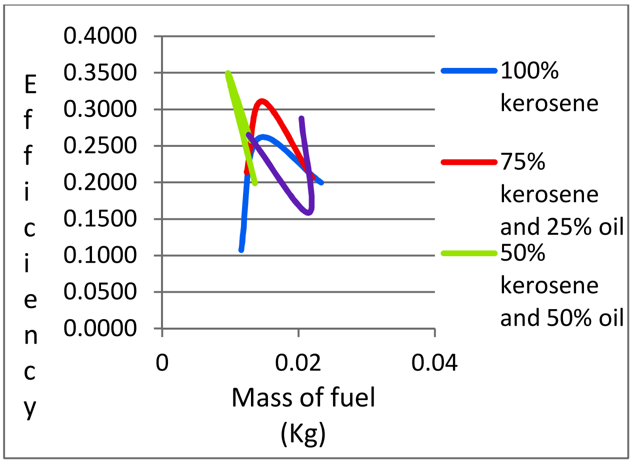


Fig. 4.2: Relation between Efficiency and Mass of Fuel

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication Pvt. Ltd.

As depicted in fig. 4.2, the efficiency is maximum with minimum fuel consumption for 50% kerosene with 50% spent soya bean oil blend. For 75% kerosene and 25% spent soya bean oil blend, efficiency increases with the increase in fuel consumption gradually then after attaining a peak value it gradually decreases with the further increase in fuel consumption. Similar relation is observed in the case of 100% kerosene. Paradoxically, for 25% kerosene and 75% spent soya bean oil blend, efficiency decreases gradually with the increase in the fuel consumption and after attaining a certain point (at 15% of efficiency and nearly 0.022 kg of fuel), the efficiency increase

IV. OVERALL CONCLUSIONS

The conclusions regarding the work done on the existing stove are as follows:-

1. After carrying out the experimentation we came to know that we can use waste cooking oil as alternative fuel in place of kerosene.
2. By using waste cooking oil we can reduce the effect of various diseases on human being by reducing its consumption as cooking oil.
3. By using such reused oil for cooking it gives invitation to various diseases like fatness, heart diseases etc as previously mentioned.
4. Also we found better efficiency of about 38% for 50%
   Kerosene with 50% oil blends when used as a fuel. So this gives us the further scope of using it as a fuel.

A. Future scope

1. We are trying to make changes in burner design to pro Vide preheating so that amount of fuel required will be less.

2. The method of pumping to increase the pressure requires More efforts therefore it has to be replaced by introducing New pumping mechanism

3. We are also trying to introduce the magnet in the stove this will decluster the fuel molecules and due to which Efficient burning of fuel takes place.

4. By increasing the turbulence, the fuel burns efficiently, So focus is on this too.

REFERENCES

[1] Paritosh Rustogi , Shivang Batra, **"Kerosene Bubbler Stove"**, Proceedings of 4th SARC International Conference, 30thMarch 2014, Nagpur, India, ISBN.978-93-82702-70-2.

[2] Nelson Sakosono, **"Magnetizing Kerosene For Increasing Combustion Efficiency",** JURNAL TEKNOLOGI, *Edisi* No. 2, Juni 2005, 155-162 ISSN 0215-1685.

[3] M.S.Murthy, S.A.Agiwala, M.A.Bharambe, A.Mishra and A.Raina, **"Modified Kerosene Stove for Burning High Percentage Non Edible Straight Vegetable Oil Blends",** S.S.B.T College of Engineering and Technology, Jalgaon Published in Clean Energy and Technology (CET), 2011 IEEE First Conference on Date of:27-29 June 2011.

[4] Anil K Rajvanshi , S M .Patil and B.Mendoca, **"Development Of Stove Running On Low Ethanol Concentration"**, Nimbkar Agricultural Research Institute(*NARI*) , Nov 2004, Phaltan.

[5] Article: Tropentag of Kassel-Witzenhausen And University Of Gottingen October 9-11, 2007, **"Development Of A Plant Oil Pressure Stove"**.

[6] Dan Li, WenjunFang , **"Preparation And Stability Of Silver/Kerosene Nanofluids" ,** Department of Chemistry and Chemical Engineering, Weifang University, Weifang , Shandong Province , 261061, China.
Department of Chemistry, Zhejiang University , Hangzhou, Zhejiang Province, 310027, China Corresponding author. Danli :danli830109@163.com ; Wenjun Fang :fwjun@zju.edu.cn .Received March 22, 2012; Accepted July 2,2012.Copyright©2012 Li and Fang; licensee Springer (Nanoscale Res Lett. 2012; 7(1): 362.PMCID: PMC3464727)

[7] R. Natarajana , N. S. Karthikeyana , Avinash Agarwaal, K. Sathiyanarayanan, **"Use Of Vegetable Oil As Fuel To Improve The Efficiency Of Cooking Stove"**, Energy Centre, School of Mechanical and Building Sciences, Vellore Institute of Technology University, Vellore 632 014, IndiaChemistry Division, School of Science and Humanities, Vellore Institute of Technology University, Vellore 632 014, IndiaReceived 7 June 2007; accepted 30 January 2008 ,Available online 28 March 2008 (ScienceDirect Renewable Energy 33 (2008) 2423-2427)

[8] Y. Nagaraju, Dr. Lasya Gopal, **"Development and Performance Assessment of a Pressurized Cook Stove Using a Blend of Pongamia Oil and Kerosene"**, The Energy and Resources Institute (TERI), Southern Regional Centre, 4thMain, 2nd Cross, Domlur 2nd stage, Bangalore – 560 071.

[9] **Mohd**. Yunus Khan, Faraz Ahmad Khan, Mirza Shariq Beg, **"Ethanol-Kerosene Blends: Fuel Option for Kerosene Wick Stove"**, International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 3, Issue 1, January -February 2013, pp.464-466.

[10] **Patent** US4605498- **"Apparatus Of Magnetic Treatment Of Liquids",** -Google Patents.

[11] K. Arumugama, S. Veerarajab and P.Esakkimuthu, **"Combustion of Waste/ Used Oil by Using Specialized Burner"**, International Journal of Applied Engineering Research.ISSN 0973-4562, Volume 8, Number 15 (2013) pp. 1839-1846 © Research India Publications http://www.ripublication.com/ijaer.htm.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.