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Dual fuel injection system in a cooking stove using biodiesel

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***ABSTRACT*-In the current era of industrialization; increment in pollution and global warming are major problems. When fossil fuels, wood and solid biomass burn they emit harmful gases. Due to this, environmental problems are becoming dangerous day by day. The UN estimated around 1.4 million women and children die every year because of inhaling fumes from wood or solid biomass burning in traditional cook stove. Biodiesel products are less toxic pollutants than other petroleum products. When bio fuels are burnt, they produce significantly less carbon output and few pollutants. Thus Bio-Diesel proves to be significant substitute for conventional fuels such as kerosene. Thus, to tackle day to day pollution Bio-Diesel stove proves to be an effective tool.**

Keywords: **Bio-Diesel stove, pollution, Bio-Diesel, less carbon output, conventional fuels.**

1. INTRODUCTION

Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever-increasing energy needs requiring huge investments to meet them.

Energy can be classified into several types based on the following criteria:

- Primary and Secondary energy
- Commercial and Non commercial energy
- Renewable and Non-Renewable energy

1.1 Energy crisis in India

In 2017 India was 3rd largest oil consumer in world (4,690,000 bbl/day). India lacks sufficient domestic energy resources and must import much of its growing energy requirements. India is not only experiencing an electricity shortage but is also increasingly dependent on oil imports to meet demand. In addition to pursuing domestic oil and gas exploration and production projects, India is also stepping up its natural gas imports, particularly through imports of liquefied natural gas. The country's ability to secure a reliable supply of energy resources at affordable prices will be one of the most important factors in shaping its future energy demand.

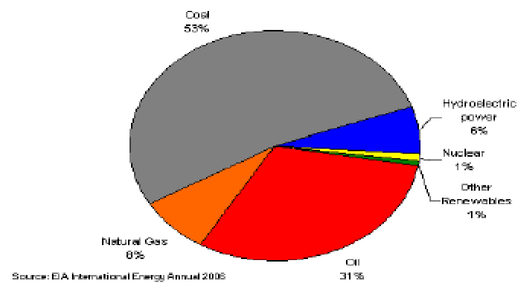

Fig.1 Total energy consumption in India

1.2 Biodiesel

Biodiesel is the most common biofuel in Europe. It is produced from oils or fats using transesterification and is a liquid similar in composition to fossil/mineral diesel. Chemically, it consists mostly of fatty acid methyl (or ethyl) esters (FAMEs). Feedstocks for biodiesel include animal fats, vegetable oils, soy, rapeseed, jatropha, mahua, mustard, flax, sunflower, palm oil, hemp, field pennycress, pongamia pinnata and algae. Pure biodiesel (B100) is the lowest emission diesel fuel. Although liquefied petroleum gas and hydrogen have cleaner combustion, they are used to fuel much less efficient petrol engines and are not as widely available.

2. LITERATURE REVIEW

Amina Junaid Sani: The Green Manager with SME Funds says a bio-fuel gel produced from sawdust, grass and waste paper is a more effective to kerosene, which is increasingly difficult to get hold of. Cook stoves are a growing source of CO2 emission around the world but do not receive the same attention as other sources of pollution, such as power stations, aviation and transport. The smoke produced from dirtier traditional stoves, generates many harmful pollutants as well as more greenhouse gases. 93500 deaths a year are linked to its use. "This is selling a dollar per liter, so it is affordable for (them), when you take it to local women in the villages you know what they are going through. It is hard to get kerosene and people are keen to use this."

Ashok Yadav, Prakash Chandra Jha: The study was done on Jatropha bio fuel stove technology. The study deals with comprehensive literature review followed by technical modifications. The wick stove proto type designed for kerosene burning was chosen for the study. The concepts for preliminary design and pre-modifications were drawn on the basis of observations received during testing of proto type to burn with Jatropha oil. Then final modifications of the wick stove were performed technically to make it compatible with burning Jatropha oil.

3. STUDY OF BIODIESEL

3.1 Properties of kerosene

Kerosene is a thin, clear liquid formed from hydrocarbons, with density of 0.78 - 0.81g/cm^3. Kerosene is obtained from the fractional distillation of petroleum between 150 °C and 275 °C, resulting in a mixture of carbon chains that typically contain between 6 and 16 carbon atoms per molecule. Calorific value of the kerosene is 43.3 MJ/kg. Flash point is around 35°C. (Flash point is the temperature at which momentary flash of flame will be induced and after that it burns continuously).

3.2 Properties of Bio-Diesel

The bio-diesel oil is popularly known as pongamia oil or karanja oil. Among the non-edible vegetable oils, the bio-diesel oil is termed as one of the better fuels for internal combustion engines. The bio-diesel oil is extracted from the seeds of bio-diesel tree also called karanja tree. The scientific name of Karanja tree is Pongamia Pinnata Linn. The name, 'Pongamia' has been coined from the Tamil name of the plant 'Pongam'; in Western India the tree goes under the name of Karanj, and it is probably due to the abundance of such trees in the area that the Island of Karanjia, near Mumbai was so named. The tree is occasionally seen on roadsides in peninsular India; it is indigenous throughout India from the foothills of the Himalayas down to the south of the Peninsula especially not far from the seacoasts. Karanja tree stands tall with some trees being over 30 m high. Karanja tree can grow on moist soil types ranging from stony to sandy to clayey. It does not do well on dry sands but it is highly tolerant to salinity.

Fig.2 Bio-diesel tree

Fig. 3 Bio-diesel pods and seeds

3.3Cultivation of Bio-Diesel Seeds and Extraction of Oil

Pongamia is easily established by direct seeding or by planting nursery-raised seedlings or stump cuttings of 1-2 cm root-collar diameter. Propagation by branch cuttings and root suckers is also possible. In peninsular India, the seeding season is April to June, and the seed yield per tree ranges from about 10 kg to more than 50 kg. There are 1500-1700 seeds per kg. The pods are dried in sun & seeds are extracted by thrashing the fruits. They remain viable for about a year when stored with the fruit shell un- opened in air-tight containers. Generally seeds do not require any pretreatment before sowing. But, soaking the seeds in hot water for 15 minutes improves germination percent & vigour. Seed germinates within two weeks of sowing. Seedlings attain a height of 25-30 cm in their first growing season. Transplanting to the field should occur at the beginning of the next rainy season when seedlings are 60 cm in height. Seedlings have large root systems. Soil should be retained around the roots during transplanting. Seedling survival and growth benefit from annual weed control for the first three years after transplanting. The plant starts giving yield from the fifth year onwards. Seeds are collected and oil is extracted using machine shown in fig. machine has capacity to crush 50 kg seed per hr.

Table 1: Properties of Bio-Diesel

PROPERTIES	VALUES
Density(kg/m3)	927
Calorific value(kJ/kg)	39400
Cetane number	40
Viscosity(cst)	56
Flash point (0C)	250
Carbon residue (%)	0.66

Properties of bio-diesel oil are not suitable for direct use. Its properties should be improved so that its performance is enhanced and appropriate results are achieved.

3.4Physico-Chemical properties of Bio-Diesel oil

The Bio-Diesel oil is bitter, red brown, thick, non-drying and non-edible. The physical and chemical properties of vegetable oil are important for combustion and storage as fuel. A comparison of physico-chemical properties of bio-diesel oil and diesel is given in Table

Table 2: Comparison of physico-chemical properties of Bio-Diesel oil and diesel

S. No.	Parameters	Bio-Diesel oil	Diesel
1	Saponification Value	185 - 195	0
2	Iodine value	80 - 90	38.30
3	Acid Value (Max.)	20	0.06
4	Moisture (% max.)	0.25	24.66

5	Colour in ¼ inch cell (Y+5R)	40	102.5
6	Refractive Index (40^0C)	1.473 – 1.479	1.472
7	Specific Gravity (30^0C)	0.90 – 0.94	0.82 – 0.86
8	Cloud Point (^{0}C)	15	13
9	Pour Point (^{0}C)	-2 to -5	1

3.5Chemical Composition

Bio-Diesel oil is reported to contain alkaloids demethoxykanugin, gamatay, glabrin, glabrosaponin, kaempferol, kanjone, kaugin, neoglabrin, pinnatin, pongamol, pongapin, quercitin, saponin, β-sitosterol, and tannin. Air-dry kernels have 19 % moisture, 27.5 % fatty oil, 17.4 % protein, 6.6 % starch, 7.3 % crude fiber, and 2.4 % ash. Destructive distillation of wood on a dry basis yields, Charcoal 31 %, pyroligneous acid 36.69 %, acid 4.3 %, ester 3.4 %, acetone 1.9 %, methanol 1.1 %, tar 9 %, pitch and losses 4.4 % and gas $0.12m^3$/kg. Manurial values of leaves and twigs are respectively: Nitrogen 1.16, 0.71; Phosphorous (P_2O_5) 0.14, 0.11; Potash (K_2O) 0.49, 0.62; and Lime (CaO) 1.54, 1.58%. Fatty acid composition of Bio-Diesel oil is given in the table below

Table 3: Fatty acid composition of Karanja oil*

S. No.	Fatty acid	Structure	Formula	Wt %
1	Palmitic	16:0	C16H32O2	3.7–7.9
2	Stearic	18:0	C18H36O2	2.4–8.9
3	Lignoceric	24:0	C24H48O2	1.1–3.5
4	Oleic	18:1	C18H34O2	44.5–71.3
5	Linoleic	18:2	C18H32O2	10.8–18.3
6	Arachidic	22:0	C20H40O2	2.2-4.7
7	Behenic	22:0	C22H44O2	4.2-5.3
8	Eicosenoic	20:1	C20H38O2	9.5-12.4

Vegetable oil has higher viscosity and lower volatility and causes improper atomization of fuel during injection. This leads to smoky exhaust in a diesel engine. The other problems are clogging of nozzle orifice, poor atomization and vaporization and results in incomplete combustion. The higher viscosity of oil changes the spray pattern and droplet size. The longer engine trials have resulted in injector chocking engine deposits, ring sticking, thickening of engine and lubricating oil which reduces engine life shows the wax depositions on the filter element with engine operation on Bio-Diesel oil. The polyunsaturated nature of the vegetable oil causes long-term problems due to slow polymer gum formation causing ring sticking. Because of these problems, vegetable oils need to be converted into more compatible fuels for existing engines. The fuel modification is mainly aimed at reducing the viscosity and increasing volatility.

3.6 Methods of reducing viscosity

- Preheating of vegetable oils.
- Transesterification of vegetable oils.
- Blending with diesel.
- Emulsification.
- Dual fuelling with gaseous and liquid fuels.
- Use of low heat rejection (LHR) engine.

3.6.1Preheating of vegetable oils

The viscosity of vegetable oils can be reduced by heating them prior to injection. By preheating the vegetable oils to about 55°c the viscosity becomes almost equal to that of kerosene. When vegetable oils are preheated, viscosity reduces exponentially with temperature. This will improve the spray characteristics and fuel air mixture preparation in the engine. Preheating is known to reduce viscosity of vegetable oil to acceptable range. Preheated vegetable oils results in improved performance with a reduction in emissions.

3.6.2 Transesterification

Trans-esterification is the chemical process of converting vegetable oils into diesel like fuel . In transesterification process, a triglyceride reacts with three molecules of alcohol in the presence of a catalyst, producing a mixture of fatty acids and glycerol. A specified amount of methanol or ethanol is mixed and allowed to react with the vegetable oil in the presence of a catalyst like NaOH or KOH at a temperature of 70^0C. Conversion of vegetable oil to biodiesel is affected by different parameters namely time of reaction, reactant ratio (Molar ratio of alcohol to vegetable oil), type of catalyst, amount of catalyst, temperature of reaction. To complete a transesterification process stoichiometrically 3:1 molar ratio of alcohol to triglycerides is needed. However, in practice, higher ratio of alcohol to oil ratio is generally employed to obtain biodiesel of lower viscosity and high conversion. The effect of transesterification is to reduce the level of free fatty acid

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(FFA) greatly and reduce the viscosity, boiling point, flash point and for removal of the complete glycerides from the vegetables oils. In the process cetane number is also improved. It has been reported that the methyl ester of vegetable oils offers low smoke levels and high thermal efficiencies than neat vegetable oils.

The methyl ester of vegetable oils leads to improved heat release rates. Power output was found to be superior to pure vegetable oils. However, the transesterification process requires approximately three hours for making the ester and a further 12 hours for separation. It also results in by products such as fatty acids and glycerol. These cannot be used as fuels in engines though they have other uses. This process is one of the reversible reactions and proceeds essentially by mixing the reactants. However, the presence of the catalyst accelerates the conversion.

Fig.4 Separation of HOME and Glycerine.

Table 4: Properties of HOME

PROPERTIES	VALUES
Density(kg/m3)	927
Calorific value(kJ/kg)	39400
Cetane number	40
Viscosity(cst)	56
Flash point (0C)	250
Carbon residue (%)	0.66

Fig.5 A view showing Bio-Diesel oil and HOME.

4. DESIGN OF BIODIESEL STOVE

4.1Constructional Details of Biodiesel Stove
It consists of 2 cylinder tanks. The right tank is for kerosene and the left tank for the Bio-Diesel oil. The left side tank is located at some elevation for the gravity flow of Bio-Diesel oil. Three valves are provided, one to control the oil flow from the kerosene tank, second valve to control the oil flow from Bio-Diesel oil tank to the copper tube, third to control the oil flow from copper tube to the burner. Pressure gauges are provided to indicate the pressures built up in tanks. Three windings are surrounding the burner. Two pressure relief valves are provided. The details of each are as follows

- Bio-Diesel tank: The Bio-Diesel tank is located to the left and is at some elevation for the gravity flow of Bio-Diesel oil.
- Kerosene tank: The kerosene tank is located at the right side.
- Valves: The Bio-Diesel stove consists of three valves. One to control the oil flow from the kerosene tank, second valve to control the oil flow from Bio-Diesel oil tank to the copper tube, third to control the oil flow from copper tube to the burner.

Fig.6 Flow control valve

- Copper tube winding: Copper coil is wounded around the burner for heating purpose of Bio-Diesel to reduce its viscosity.
- Frame: It acts as a base and supports both the tanks.
- Pressure gauges and pressure relief valves: Two pressure gauges are provided to indicate the pressures built up in tanks. Pressure relief valves are used to release the pressure during working.

Fig.7 Pressure gauge

4.2Machines Used

During manufacturing some machines used they are as follows.

- Hack Saw
- Brazing machine
- Spray painting.

4.3Operations Used

- Brazing is done for copper tubes
- Brazing is suitable for small parts and when high strength of joint is required
- Brazing takes place above 840 F but bellow melting point of base metal i.e. copper. So it is best suitable for copper.

Fig.8 After brazing process

- Bending is used for bending of copper tubes into required diameter i.e. 130 mm
- Three turns of copper winding are done around burner
- Bending is also performed at some locations to change the direction of the copper tube.

Fig.9 During bending process

Fig.10 Copper tube after bending

5. WORKING

Initially the stove is made to run with kerosene by operating valve one, keeping valve two and three closed. The stove is made to operate for 10-15 minutes till a steady flame is obtained. Now the copper tube gets heated up and valve two is opened to allow the flow of viscous Bio-Diesel oil to the copper tube. As the oil circulates through the copper tube its viscosity reduces. Now valve one is closed and by operating valve three, the less viscous Bio-Diesel oil is made to flow to the burner and stove continues to operate on Bio-Diesel oil.

6. ADVANTAGES AND DISADVANTAGES OF BIODIESEL STOVE

6.1 Advantages of Bio-Diesel oil Stove

- The kerosene starts and Bio-Diesel run stove cost effective in terms of fuel consumption.
- Bio-Diesel oil is a renewable source of energy. It can be extracted from Bio-Diesel trees again and again.
- The extraction of Bio-Diesel oil from the trees is simple as compared to fractional distillation of production of kerosene.
- The oil extraction equipment is portable.
- The efficiency of kerosene start Bio-Diesel run stove is comparatively more than kerosene stove.

- Soothing is reduced up to greater extent.
- The Bio-Diesel oil emits less harmful gases on combustion hence the stove is environmental friendly.

6.2 Disadvantages of Bio-Diesel oil Stove:

- Use of kerosene is not totally eradicated as it is necessary for preheating of Bio-Diesel oil.
- Since two cylinders are used the stove takes more floor space as compared with other stoves.
- The process of starting the stove & maintaining pressure in both the cylinders is a bit tedious task.
- Manufacturing of the stove takes more time & resources.
- Since viscosity of Bio-Diesel oil is high, it cannot be used for burning directly. Preheating is a must.
- Due to high viscosity complete vaporization is not possible.

7. CONCLUSION

As kerosene is a major source of fuel for various purposes , majority of it is being consumed for cooking, in villages .Also it is predicted that fossil fuels are expected to get extinct by around 2024 so it is high time that we need to think for an alternative source for consumption of fossil fuels for cooking though the proposed project does not totally nullifies the use of kerosene but takes care that the consumption of the same is made less but promises to be one of the sources to almost cut down the use of kerosene oil by around 80% than the conventional stoves. The design parameters and working of the stove such as:

- Use of stainless steel tube around the burner instead of copper tube
- Using three turn of the tube around the burner.
- Increasing the size of the burner.
- Adopting silent type of burner instead of roarer type burner.
- Gauge thickness of the tube has to be increased.
- Safety measures have to be taken care of while operating the stove at high pressures.
- To make the stove to run on other biofuels also to seek for feasibility of operation.
- An easy technique to reduce the viscosity of raw Bio-Diesel oil in the tank itself.

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