Performance Evaluation of Diesel Engine Using Jatropha Oil with Exhaust Heat Recovery System

Seemab Ahmad Zaidi[1], Prakher Dubey[2]
M.Tech. Scholar, Mechanical Engineering Dept., SSSUTMS, Sehore, Madhya Pradesh, India[1]
Assistant Professor, Mechanical Engineering Dept., SSSUTMS, Sehore, Madhya Pradesh, India[2]

Abstract: *The world is being modernized and industrialized day by day. As a result vehicles and engines are increasing. But energy sources used in these engines are limited and decreasing gradually. The rapidly depleting conventional petroleum resources have promoted research for alternative fuels for diesel engines. Bio-fuel, a promising substitute as an alternative fuel has got significant attention due to the limited sources of conventional fuels and environmental concern. From different possible options, fuels derived from vegetable oil present promising renewable substitutes for fossil fuels. The utilization of Straight vegetable oil fuel in diesel engine fuel has main the advantage of eliminating the energy, cost and time consumed in biodiesel production. Oil derived from Jatropha curcas plant has been considered as a sustainable alternate fuel for diesel engine. The use of straight vegetable oil encounters problem due to its high viscosity, poor volatility and cold flow. The purpose of this study is to reduce the viscosity of oil by effectively utilization of waste heat from exhaust gases before fed to inlet and favourable properties compared to diesel can be obtained.*
Keywords: *Diesel engine, Jatropha, Straight Vegetable oil.*

1. Introduction

In our present day lifestyle, the internal combustion engines have already become an indispensable and integral part, particularly in the transportation and agricultural field. CI engines are the most trusted power sources which are preferred in the transportation industry also. Due to the problems of fuel crisis and environmental pollution, the survival of these engines has been threatened. Therefore to protect the global environment, it's become necessary to search an alternative of oil as energy source. Among different clean burning sources, bio-fuel obtained from vegetable oils seems to be more efficient because of its renewable and clean burning property similar to mineral diesel. The use of edible vegetable oils for bio-fuel production has recently been of great concern because they compete with food materials. As the demand for vegetable oils for food has increased tremendously in recent years, it is impossible to justify the use of these oils for fuel use purposes such as bio-fuel. Moreover, these oils could be more expensive to use as fuel. Hence, the contribution of non-edible oil will be significant as a non edible plant oil source for biodiesel production. Moreover, these oils could be more expensive to use as fuel.

1.1 Why "Bio fuels"?

Nowadays, research have been made to use vegetable oil, animal fats as an alternate source of renewable energy known as bio-fuel that can be used as fuel in CI engines. Bio-fuels appear to be a potential alternative "greener" energy substitute for fossil fuels [1]. It is renewable and available throughout the world. The idea of using vegetable oils as fuel for diesel engines is not new [2]. Bio-fuels are generally considered as offering many properties, including sustainability, reduction of greenhouse gas emission regional development, social structure and agriculture, security of supply [3].Vegetable oils are considered as most sustainable alternative fuels for CI engines as they are renewable, biodegradable, non toxic, environmental friendly, a lower emission profile compared to diesel fuel and most of the situation where conventional petroleum diesel is used. Non edible vegetable oils are the most significant to use as a fuel compared to edible vegetable oils as it has a tremendous demand for using as a food and also the high expense for production. Therefore many researchers are experimenting on non edible vegetable oils. In India the feasibility of producing bio diesel as diesel substitute can be significantly thought as there is a large junk of degraded forest land, unutilized public land, and fallow lands of farmers, even rural areas that will be beneficial for overall economic growth. . The use of vegetable oils, such as palm, soya bean, sunflower, peanut, and olive oil, Jatropha curcas etc. as alternative fuels for diesel is being promoted in many countries [4]. Only a very few and non-edible type such as jatropha oil, karanja oil, etc. can be considered to be eco nominally afford able to some developing countries like India in particular [8]. The Jatropha curcas Linnaeus plant J. curcas L. belongs to the family Euphorbiaceae. The genus name Jatropha derives from the Greek jatros (doctor), trophe (food), which implies medicinal uses, hence the plant is traditionally used for medicinal purposes. It is a hardy shrub that can grow on poor soils and areas of low rainfall (from 250 mm a year) hence its being promoted as the ideal plant for small farmers [11-12]. It is a drought-resistant, perennial plant and living up to fifty years and has capability to grow on marginal soils. It requires very little irrigation and grows in all types of soils (from coast line to hill slopes). It is a rapidly growing tree and easily propagated. Jatropha usually grows below 1400 meters of elevation from sea level and requires a minimum rainfall of 250mm, with an optimum rainfall between 900-1200mm [10]. It is non-edible oil being singled out for large-scale for plantation on waste lands Jatropha plant can thrive under adverse conditions. The production of jatropha seeds is about 0.8 kg per square meter per year. The oil content of jatropha seed ranges from 30% to 50% by weight and the kernel itself ranges from 45% to 60%. Fresh jatropha oil is slow-drying, odor less and color less oil, but it turns yellow after aging [9].

A) The Cultivation of the Jatropha plant Jatropha curcas L. has various socio-economic benefits which makes it more economical when cultivated on commercial scale. Jatropha can be propagated from seeds as well as from cuttings. Seeds or cutting can be directly planted in the main field. Otherwise, seedlings grown in poly bags are transplanted in the main field. A hectare of jatropha plantation is reported to yield 2.5-3.5tonnes of seeds in the third year and increases sharply to 5000-12,000 tonnes per hectare from the sixth year onwards [6].

B) Jatropha as a plant of many uses

Rural energy problems in developing countries and are linked with other rural problems. These problems need an integrated approach to reach solutions. The Jatropha plant has four main contributions to rural development and poverty eradication in general: Renewable energy, promotion of women, poverty reduction and soil erosion control. The Jatropha Curcas has many products and potential contributions to rural community development. The products of the Jatropha plant are the plant itself, fruits, leaves, and latex. The fruits comprise of seeds and fruit hulls. The seeds produce seed oil, seed cake, and seed shells. The oil processes also produce sediments from oil purifications. The Jatropha plant itself can be used in erosion control if planted across the hills and against the wind. The plant can also be used as firewood. The fact that it grows very fast means Jatropha can be used to solve the problems of deforestation in many developing countries. The toxicity of the plant deters animal browsing. The leaves are used as a medicine and could also be used to develop Silkworm. The leaves can also be used as an anti-inflammatory substance. The Jatropha plant also provides a source of employment to many rural areas, which in turn helps to reduce urban migration in developing countries.

C) Toxicity of the Jatropha plant

The toxicity of the Jatropha Curcas is an advantage on one side and disadvantage on the other. The advantage emanates from the fact that the plant leaves cannot be browsed by animals and could act as an excellent fence. The disadvantage comes from the fact that the equipment, such as ram presses that are used to press Jatropha seeds, could not be used to press other edible seed oil from plants like sunflower unless a thorough cleaning is done which would take a lot of environmental resources. The claims that there are some varieties of non-toxic Jatropha plants need more investigation.

1.2 Characterization of jatropha oil

Non-edible oil generally contains about 3-4 %wax and gum. De-waxing and degumming of plant oils is required not only for smooth running of the CI engine but also to prevent engine failure even if plant oils are blended with diesel. It is therefore necessary to remove wax and gum from the fresh oil before it could be used in CI engine. Analysis of Jatropha seeds revealed that the percentage of crude protein, crude fat and moisture were 24.60, 47.25 and 5.54% respectively (Akintayo, 2004).Characterization of diesel and Jatropha oil is as per the [Table–1]. Crude-Jatropha oil, a non-edible vegetable oil shows a greater potential for replacing conventional diesel fuel quite effectively, as its properties are compatible to that of diesel fuel [5]. It is however found from researches that the neat jatropha oil can be used to run the engines in mini-vans for rural transportation, haulage trucks, farm tractors and other agricultural machinery, but may require little modification [7].

From the below table 1, Density, cloud point and pour point of Jatropha oil are found to be higher than diesel. Higher cloud and pour point reflect unsuitability of Jatropha oil as diesel fuel in cold climatic conditions but the flash and fire points of Jatropha oil is very high compared to mineral diesel. Hence, Jatropha oil is extremely safe to handle [14]. Higher carbon residue from Jatropha oil may possibly lead to higher carbon deposits in combustion chamber of the CI engine. Low sulphur content in Jatropha oil results in lower SOX emissions. Presence of oxygen in fuel improves combustion properties and emissions but reduces the calorific value of the fuel [14]. Jatropha oil has approximately 90% calorific value compared to diesel. Nitrogen content of the fuel also affects the NOX emissions. Higher viscosity is a major problem in using vegetable oil as fuel for diesel engines. Viscosity of Jatropha biodiesel is 4.84cSt at 40°C. It is observed that viscosity of Jatropha oil decreases remarkably with increasing temperature and it becomes close to diesel at temperature above 90°C [15].

Table 1: Comparison of properties of Jatropha oil with diesel [13-pranik]

Sr. No	Parameter	Diesel	Jatropha. curcas oil
1	Energy content (MJ/kg)	42-46	38.2
2	Density (gm/cc), 30°C	0.836–0.850	0.93292
3	Kinematic viscosity (cSt), 30°C	4.2	55
4	Specific Weight (15/40 °C)	0.84-0.85	0.91-0.92
5	Solidifying point (°C)	-14.0	2.0
6	Flash point (°C)	80	180
7	Fire point (°C)	78	256
8	Pour point (°C)	-6	6
9	Ignition point (°C)	257	340
10	Cetane value	40-55	38-40
11	Sulphur (%) by Wt	1.0-1.2	0-0.13
12	Oxygen (%, w/w)	1.19	11.06
13	Carbon (%, w/w)	86.83	76.11
14	Hydrogen (%, w/w)	12.72	10.52
15	Ash Content (%, w/w)	0.01±0.0	0.03±0.0

1.3 Advantages of Jatropha

- Hardy shrub which grows in semi-arid conditions and poor soils
- Can be intercropped with high value crops such as sugar, coconut palm, various fruits and vegetables, providing protection from grazing livestock and phyto-protection action against pests and pathogens
- It is easy to establish and grows relatively quickly.
- Yields around 4 tons of seed per hectare in unkept hedges are achievable
- Has low nutrient requirements
- Requires low labor inputs.
- Bio-fuel almost completely eliminates life cycles CO_2 emission.
- Production of 1t / ha / year of high protein seed cake that can be used as animal and fish feeds and organic matter that can be used as organic fertilizers.
- Various other products from the plant (leaf, bark and seed extracts) have various other industrial and pharmaceutical uses.
- Restoration of degraded land over a period of time.
- Rural employment generation
- The highest cetane no. of bio-diesel compared to petro diesel indicates potential for higher engine performance.
- The superior lubricating properties of bio- diesel increases functional engine efficiency.
- Their higher flash point makes them to safer to store.
- The bio-diesel molecules are simple hydrocarbon chains, contains no sulfur or aromatic substances associated with fossil fuels.
- They contain higher amount of O_2 (up to 10%). That ensures more complete combustion of HC.

1.4 Economics benefits

- Increase employment activity and increase Employment on the countryside
- Emits up to 100% less sulfur dioxide
- Reduces smoke particulates at about 75%

1.5 Disadvantages of Jatropha

- Low volatility.
- High pour points, cloud points and cold filter plugging.
- Higher NOX emissions at elevated temperatures.
- Incomplete combustion.
- Seeds and leaves are toxic to human beings and animals
- Toxicity is based on several components (phorbol esters, curcains, trypsin inhibitors and others) which make complete detoxification a complicated and difficult process.

2. Literature Review

Rudolf Diesel (1900) demonstrated his engine running on 100% peanut oil at World Exhibition in Paris.[16] . Seddon (1942) experimented with using several different vegetable oils in a Perkins P 6 diesel engine with great success during World War II. The results of this experiment showed that vegetable oils could be used to power a vehicle under normal operating conditions. However, it was noted that much more work was needed before vegetable oils could be used as a reliable substitute for diesel fuel.[17]Bruwer et al. (1980) studied the use of sunflower seed oil as a renewable energy source. When operating tractors with 100% sunflower oil instead of diesel fuel, an 8% power loss occurred after 1000 hours of operation. The power loss was corrected by replacing the fuel injectors and injector pump. After 1300 hours of operation, the carbon deposits in the engine were reported to be equivalent to an engine fueled with 100% diesel except for the injector tips, which exhibited excessive carbon build- up.[18]Goering et al. (1981) studied the characteristic properties of eleven vegetable oils to determine which oils would be best suited for use as an alternative fuel source. Of the eleven oils tested, corn, rapeseed, sesame, cottonseed, and soybean oils had the most favorable fuel properties [19].

Yarbrough et al. (1981) experienced similar results when testing six sunflower oils as diesel fuel replacements. Raw sunflower oils were found to be unsuitable fuels, while refined sunflower oil was found to be satisfactory. Degumming and dew axing the vegetable oils were required to prevent engine failure even if the vegetable oils were blended with diesel fuel [20]. Tahir et al. (1982) tested sunflower oil as a replacement for diesel fuel in agricultural tractors. Sunflower oil viscosity was 14% higher than diesel fuel at 37°C. Engine performance using the sunflower oil was similar to that of diesel fuel, but with a slight decrease in fuel economy. Oxidation of the sunflower oil left heavy gum and wax deposits on test equipment, which could lead to engine failure [21]. Bacon et al. (1981) evaluated the use of several vegetable oils as potential fuel sources. Initial engine performance tests using vegetable oils were found to be acceptable, while noting that the use of these oils caused carbon build up in the combustion chamber. Continuous running of a diesel engine at part load and mid-speeds was found to cause rapid carbon deposition rates on the injector tips. Short 2-hour tests were used to visually compare the effects of using different vegetable oils in place of diesel fuel. Although short-term engine test results were promising, Bacon recommended long-term engine testing to determine the overall effects of using vegetables oils as a fuel in diesel engines [22].

Reid et al. (1982), evaluated the chemical and physical properties of 14 vegetable oils. These injection studies pointed out that the oils behave very differently from petroleum-based fuels. This change in behavior was attributed to the vegetable oils high viscosity. Engine tests showed that carbon deposits in the engine were reduced if the oil was heated prior to combustion. It was also noted that carbon deposit levels differed for oils with similar viscosities, indicating that oil composition was also an important factor [23]. Schoedder (1981) used rapeseed oils as a diesel fuel replacement in Germany with mixed results. Short term engine tests indicated rapeseed oil had similar energy outputs when compared to diesel fuel. Initial long-term engine tests showed that difficulties arose in engine operation after 100 hours due to deposits on piston rings, valves, and injectors. The investigators indicated that further long-term testing was needed to determine if these difficulties could be adverted [24]. Auld et al. (1982) used rapeseed oil to study the effects of using an alternative fuel in diesel engines. An analysis of the rapeseed oil showed a relationship between viscosity and fatty acid chain length. Engine power and torque results using rapeseed oil were similar to that of diesel fuel. Results of the short-term tests indicated further long term testing was needed to evaluate engine durability when rapeseed oil was used [25]. Bettis et al. (1982) evaluated sunflower, safflower, and rapeseed oils were evaluated as possible sources for liquid fuels. The vegetable oils were found to contain 94% to 95% of the energy content of diesel fuel, and to be approximately 15 times as viscous. Short-term engine tests indicated that for the vegetable oils power output was nearly equivalent to that of diesel fuel, but long-term durability tests indicated severe problems due to carbonization of the combustion chamber [26]. Pryde (1982) reviewed the reported successes and shortcomings for alternative fuel research. This article stated that short-term engine tests using vegetable oils as a fuel source was very promising. However, long-term engine test results showed that durability problems were encountered with vegetable oils because of carbon buildup and lubricating oil contamination. Thus, it was concluded that vegetable oils must either be chemically altered or blended with diesel fuel to prevent premature engine failure [27].

Engler et al. (1983) found that engine performance tests using raw sunflower and cottonseed vegetable oils as alternative fuels gave poor results. Engine performance tests for processed vegetable oils produced results slightly better than similar tests for diesel fuel. However, carbon deposits and lubricating oil contamination problems were noted, indicating that these oils are acceptable only for short-term use as a fuel source [28]. Pryor et al. (1983) conducted short and long-term engine performance tests using 100% soybean oil in a small diesel engine. Short- term test results indicated the soybean performance was equivalent to that of diesel fuel. However, long- term engine testing was aborted due to power loss and carbon buildup on the injectors [29]. In CI engine, more than 30 different vegetable oils have been used to operate compression engines since the 1900’s (Quick, 1980) [30]. Initial engine performance suggests that these oil-based fuels have great potential as fuel substitutes. Extended operation indicated that carbonization of critical engine components resulted from the use of raw vegetable oil fuels, which can lead to premature engine failure. Blending vegetable oil with diesel fuel was found to be a method to reduce coking and extend engine life. Studies involving the use of raw vegetable oils as a replacement fuel for diesel fuel indicate that a diesel engine can be successfully fuel with 100% vegetable oil on a short-term basis. However, long-term engine durability studies show that fueling diesel engines with 100% vegetable oil causes engine failure due to engine oil contamination, stuck piston rings, and excessive carbon build-up on internal engine components. Therefore 100% unmodified vegetable oils are not reasonable diesel fuel replacements. The gases like hydrogen and CNG are introduced in air intake manifold. This duel fuel mode allows bio- diesel to perform nearly as diesel. In such experiment, Venkatesan M. investigated the performance of diesel engine running on Jatropha oil Methyl ester and CNG in duel fuel mode [32].

S.K. Haldar et.al [31] this paper investigates non- edible straight vegetable oils of Putranjiva, Jatropha and Karanja to find out the most suitable alternative diesel by a chemical processing. Degumming is an economical chemical process that is done by concentrated phosphoric acid. This process is applied to the above-mentioned non-edible oils to remove the impurities for the improvement of viscosity, cetane number and better combustion in the diesel engine upto certain blend of diesel and non-edible vegetable oils. Ten percent, 20%, 30% and 40% blends of degummed non-edible oils and diesel are used in a Ricardo variable compression engine to study and compare the performance and emission characteristics. It is observed that the non-edible oil of Jatropha gives the best results related to the performance and emissions at high loads and 45° bTDC injection timing. S. Naga Sarada et.al [33] used LHR engine with carbureted methanol and crude jatropha oil, which showed improved performance and decreased pollution levels in comparison with conventional engine with pure diesel as fuel. It is reported that LHR engine decreased pollution levels of Smoke and Aldehydes, compared to the conventional engine with alcohol operation. A.SIVA KUMAR et.al [34] conducted the performance test using Fish oil & Jatropha oil as fuels in a diesel engine and reported that Air-fuel ratio; volumetric efficiency, Mechanical efficiency, Brake thermal efficiency and Indicated thermal efficiency are increasing indicating that bio-diesel is better than diesel. However there are a few drawbacks like higher flash and fire points, viscosity and the percentage of carbon residue for bio-diesel are more when compared to diesel.

K. Pramanik et.al. [38] conducted performance test using blends and jatropha oil was evaluated in a single cylinder C.I. engine and compared with the performance obtained with diesel. He found that the blend up to 50%of Jatropha oil mixed with diesel was proved to be the best suitable oil without modification of engine and without preheating of oil before entering into the combustion chamber. V.Edwin Geo et.al [35] exhibited the experimental results which showed that increase in brake thermal efficiency from 26.56 % to 28.40 % when the fuel was preheated to a temperature of 150°C. The CO and smoke emission of preheated RSO reduced by 29 % and 34 % respectively at 150°C compared to RSO at 30°C. It indicated faster heat release and lead to higher thermal efficiency. It was also concluded that the performance, combustion and emission parameters were improved for preheated RSO compared to raw RSO at 30°C (without preheating) but it was still inferior to diesel. Agarwal et. al. conducted various experiments to study the effect of reducing Jatropha oil's viscosity by increasing the fuel temperature and thereby eliminating its effect on combustion and emission characteristics of the engine. The acquired data were analyzed for various parameters such as thermal efficiency, brake specific fuel consumption (BSFC), smoke opacity, and CO_2, CO and HC emissions. While operating the engine on preheated Jatropha oil performance and emission parameters were found to be very close to mineral diesel for lower blend concentrations. However, for higher blend concentrations, performance and emissions were observed to be marginally inferior [36]. Godiganur Sharanappa et.al [37] used raw mahua oil and its blend which resulted in inferior performance compared to that of diesel. By heating CMO, the viscosity reduces, at this condition the brake thermal efficiencies are significantly improved and become close to diesel. It is reported that by using CMO, bsfc and Brake thermal efficiency were improved. From the experimental findings, it is concluded that CMO could be used as diesel fuel substituted by reducing its viscosity than that of diesel achieved by preheating it to higher temperatures. O.M.I. Nwafor et.al [38] conducted the experiments, which shows CO, CO2 emissions for heated oils are slightly higher and hydrocarbon emissions are reduced compared to diesel fuel. Ignition delay was longer for unheated oils and more fuel consumption is noted. The viscosity is reduced with increase in temperature. Vara Prasad C.M, [39]conducted experiments with bio diesel derived from Jatropha. The test results revealed that 100% bio-diesel can be used satisfactorily which produces less NOx emissions and higher smoke emissions.

3. Recent Work

Chauhan et al. (2010) reported that by using a heat exchanger, preheated Jatropha oil has the potential to be a substitute fuel for diesel engines. Optimal fuel inlet temperature was found to be 80°C considering the brake thermal efficiency, brake specific energy consumption and gaseous emissions.

Yilmaz and Morton (2011) using preheated peanut, sunflower and canola oils in two DI diesel engines report a comparable engine performance and emissions. No (2011) reviewed seven non- edible vegetable oils including Jatropha oil as an alternative fuel for diesel engine.

Literature shows that up to 75 % of diesel plant oils with satisfactory engine performance could replace requirement. As mentioned above, diesel are still required (25 to 30 % of the specific fuel consumption) to supplement plant oil. Short-term engine tests carried out indicate that plant oils performed quite well. Problems occur only after the engine is operated on plant oil for longer duration of time.

Vegetable oil heating is one of the techniques to reduce its viscosity. The fuel viscosity at the fuel injector is important for good atomization and combustion. With a high fuel viscosity, fuel spray can impinge upon the walls of the combustion chamber resulting in delayed combustion and burning. If heated to very high temperatures, low viscosity of the fuel can results in poor fuel droplet penetration and poor combustion.

High viscosity of the plant oils is considered to be the major constraint although high acid value and presence of wax/gums etc. also adversely affects the engine performance.

To reduce the viscosity number of method has been tried by researcher such as;

1. Blending,
2. Transesterification,
3. Micro emulsion,
4. Pyrolysis or thermal cracking,
5. Engine setup modification [40].

3.1 Blending

Blending is the method in which Vegetable oil can be directly mixed with diesel fuel and may be used for running an engine without any modification. The blending of vegetable oil with diesel fuel in different proportion were experimented successfully by various researchers. Blend of 20% oil and 80% diesel have shown same results as diesel and also properties of the blend is almost close to diesel. The blend with more than 40% has shown appreciable reduction in flash point due to increase in viscosity. Some researchers suggested for heating of the fuel lines to reduce the viscosity. Although short term tests using neat vegetable oil showed promising results, longer tests led to injector coking, more engine deposits, ring sticking and thickening of the engine lubricant [41].

3.2 Transesterification

Transesterification is the process wherein using an alcohol (e.g. methanol, ethanol or butanol), in the presence of a catalyst, such as sodium hydroxide or potassium hydroxide, to break the molecule of the raw renewable oil chemically into methyl or ethyl esters of the renewable oil, with glycerol as a by- product. Biodiesel, defined as the mono-alkyl esters of fatty acids derived from vegetable oil or animal fat, in application as an extender for combustion in diesel engines, has demonstrated a number of promising characteristics, including reduction of exhaust emissions [41]. Transesterified, renewable oils have proven to be a viable alternative Diesel engine fuel with characteristics similar to those of Diesel fuel. The transesterification reaction proceeds with catalyst or without catalyst by using primary or secondary monohydric aliphatic alcohols having 1–8 carbon atoms [41] as follows: Triglycerides + Monohydric alcohol = Glycerin + Mono-alkyl esters.

3.3 Micro –emulsification

To solve the problem of high viscosity of vegetable oil, micro emulsions with solvents such as methanol, ethanol and butanol have been used. A micro emulsion is defined as the colloidal equilibrium dispersion of optically isotropic fluid microstructures with dimensions generally in the range of 1–150 nm formed spontaneously from two normally immiscible liquids and one or more ionic or non-ionic amphiphiles. These can improve spray characteristics by explosive vaporization of the low boiling constituents in the micelles. All micro emulsions with butanol, hexanol and octanol will meet the maximum viscosity limitation for diesel engines [41].

3.4 Cracking

Cracking is the process of conversion of one substance into another by means of heat or with the aid of catalyst. It involves heating in the absence of air or oxygen and cleavage of chemical bonds to yield small molecules [41]. The pyrolyzed material can be vegetable oils, animal fats, natural fatty acids and methyl esters of fatty acids. The Pyrolysis of fats has been investigated for more than 100 years, especially in those areas of the world that lack deposits of petroleum.

Among above methods to decrease viscosity, all the methods are based on chemical reaction on oil, for making the bio-diesel. This will add extra cost of processing because of the transesterification reaction involving chemical and process heat inputs.

In rural and remote areas of developing countries, where grid power is not available, vegetable oils can play a vital role in decentralized power generation for irrigation and electrification. In these remote areas, different types of vegetable oils are grown locally but it is not be possible to chemically process on them because of the logistics problems in rural settings. Hence using heated vegetable oils as petroleum fuel substitutes is an advisable and suitable method.

- The costs of above methods are very high compared to diesel around double due to the chemical processes.
- The heat from the exhaust can decrease the viscosity up to diesel.

The main objective of the review is to ascertain that pure jatropha vegetable oil is suitable to replace diesel in CI engines. The present work aims at developing engine performance with an appropriately designed shell and tube heat exchanger (with exhaust by-pass arrangement) for evaluation of potential suitability of preheated jatropha oil as a fuel. The bypass arrangement will be such that it could give the desired fuel temperature at inlet. The determination of performance and emission characteristics of the engine with Jatropha oil (by preheating using exhaust heat) will be done and the experimental results expected that the brake thermal efficiency (BTE) of the engine and the brake specific energy consumption emissions from the Jatropha oil to be significantly nearer to the diesel fuel during the whole experimental range

4. Results and Discussion

The results of chemical and physical properties of Jatropha oil and diesel are shown in Table 1. According to table data it's clear that the higher heating value of Jatropha oil is about 85-90% to that of diesel and the pour point is also very similar. But the flash point and the kinematic viscosity of Jatropha curcas oil is higher to be 9 to 10 times of diesel. The lower heating value of Jatropha oil indicates that a higher oil consumption than that of diesel is needed for similar power output. Similar low pour points of diesel and Jatropha oil suggest that Jatropha oil can be used at low temperatures just like diesel. Due to a higher flash point Jatropha oil is safer for storing and transporting when compared to diesel. The performance of single cylinder four stroke diesel engine setup fuelled heated Jatropha oil by exhausted heat determined at a constant engine speed of 1500 rpm, controlled within a range. Our first step is to per-heat the jatropha oil up to 80-90 °C to obtain the viscosity similar diesel and same viscosity at fuel injector. The expected outcomes are higher brake thermal efficiency up as compared to diesel and highest brake power with minimum brake specific fuel consumption. The emission of HC, CO2 and NO2 to be significantly closer compared to diesel

5. Conclusion

In this review article, it is concluded that Compared to diesel fuel, a little amount of power loss happened with vegetable oil fuel operations.

- Particulate emissions of vegetable oil fuels were higher than that of diesel fuel, but on the other hand, NO2 emissions were less.
- Raw vegetable oils can be used as fuel in diesel engines with some modifications.
- Before starting wide application, some improvements is needed as we will incorporate a device heat exchanger can be use to decrease the viscosity and thus provide smooth running of engine.

References

[1] Nwafor. Emission characteristics of diesel engine running on vegetable oil with elevated fuel inlet temperature, Biomass and Bio energy journal, 27 (2004) 507 – 511

[2] Recep Alton, Selim etinkaya b, Huseyin Serdar Y. The potential of using vegetable oil fuels as fuel for diesel engines, elsvier, Energy Conversion and Management 42 (2001) 529±538

[3] Reijnders L. Conditions for the sustainability of biomass based fuel use. Energy policy 2006;34:863-76.

[4] B.K. Barnwal, M.P. Sharma. Prospects of biodiesel production from vegetable oils in India, elsvier, Renewable and Sustainable Energy Reviews, 9 (2005) 363–378

[5] P.V. Krishna Murthy., C.M. Vara Prasad., A.V. Sita Rama Raju., M.V.S. Murali Krishna., A Comparative Study on Exhaust Emissions From High Grade Low Heat Rejection Diesel Engine With Crude Jatropha Oil. International Journal of Engineering Studies Volume 1, Number 1 (2009), pp. 25–30

[6] R. K. Henning, Combating Desertification: The Jatropha project of Mali, West Africa, Arid Lands Newsletter, Fall/Winter 1996, Issue No. 40, pp. 1-5

[7] J. Sheehan, V. Camobreco, J. Duffield, M. Graboski, H. Shapouri, Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus, Report, Midwest Research Institute, 1998, pp. 98 – 107

[8] Joshi, H. C., Biodiesel from Jatropha an Alternative Fuel for the Future, Invention Intelligence, Scientific Research Magazine, National Research Development Corporation New Delhi, Sep.-Oct. 2003, pp. 205-216

[9] Y.V.Hanumantha Rao, Ram Sudheer Voleti , A.V.Sitarama Raju and P.Nageswara Reddy Jatropha Oil Methyl Ester And Its Blends Used As An Alternative Fuel In Diesel Engine. Thermal Science: Vol. 13 (2009), No. 3, pp. 207-217

[10] Devendra Vashist et al. Comparative Study of Castor and Jatropha Oil Source And Its Methyl Ester Test On The Diesel Engine. International Journal of EngineeringScience and Technology (IJEST).

[11] Sarin R, Sharma M, Sinharay S, Malhotra RK (2007). Jatropha-Palm biodiesel blends: An optimum mix for Asia. Fuel 86: 1365-1371.

[12] Foidl N, Foidl G, Sanchez M, Mittelbach M, Hackel S (1996). Jatropha curcas L. as a resource for the production of biofuel in Nicaragua. Bioresour. Technol., 58: 77-82.

[13] S.Antony Raja, D.S.Robinson smart, and C.Lindon Robert Lee, Biodiesel production from jatropha oil and its characterization Research Journal ofChemical Sciences ,Vol.1 (1) April (2011).

[14] Yamane K, Ueta A and Shimamoto Y (2001) Influence of physical and chemical properties of biodiesel fuelson injection, combustion and exhaust emission characteristics in a direct injection compression ignition engine. Intl. J. Engine Res.4, 249-261.

[15] Y.V.Hanumantha Rao, Ram Sudheer Voleti, A.V.Sitarama Raju and P. Nageswara Reddy, Experimental investigations on jatropha biodiesel and additive in diesel engine. Indian Journal of Science and Technology Vol.2 No 4 (Apr. 2009) ISSN: 0974-6846 pp 25-31.

[16] M. C. Navindgi, Maheswar Dutta and B. Sudheer Prem Kumar, Performance Evaluation, Emission Characteristics And Economic Analysis Of Four Non-Edible Straight Vegetable Oils On A Single Cylinder CiEngine ARPN Journal of Engineering and Applied

Sciences VOL. 7, NO. 2, FEBRUARY 2012 ISSN 1819-6608

[17] Seddon, R. H. 1942.Vegetable oils in commercial vehicles. Gas and Oil Power, August: 136-146.

[18] Bruwer, J. J., B. D. Boshoff, F. J. C. Hugo, L. M. DuPlessis, J. Fuls, C. Hawkins, A. N. Vander Walt, and Engelbert. 1981. The Utilization of sunflower seed oil as renewable fuel diesel engines. In Agricultural Energy, Vol. 2, Biomass Energy/Crop Production. ASAE Publication 4-81. St. Joseph, MI: ASAE.

[19] Goering, C. E., A. W. Schwab, M. J. Daugherty, E. H. Pryde, and A. J. Heakin. 1981. Fuel properties of elevenvegetable oils. ASAE Paper Number 81-3579. St. Joseph, MI: ASAE

[20] Yarbrough, C. M., W. A. LePori, and C. R. Engler. 1981. Compression ignition performance using sunflower seed oil. ASAE Paper Number 81-3576. St. Joseph, MI: ASAE.

[21] Tahir, A. R., H. M. Lapp, and L. C. Buchanan. 1982. Sunflower oil as a fuel for compression ignition engines. Vegetable Oil Fuels: Proceedings of the International Conference on Plant and Vegetable Oils Fuels. St. Joseph, MI: ASAE.

[22] Bacon, D. M., F. Brear, I. D. Moncrieff, and K. L. Walker. 1981. The use of vegetable oils in straight and modified form as diesel engine fuels. Beyond the Energy Crisis --Opportunity and Challenge Volume III. Third International Conference on Energy Use Management. Berlin (West). Eds. R. A. Fazzolare and C. R. Smith, 1525-33. Pergamon Press, Oxford.

[23] Reid, J. F., A. C. Hansen, and C. E. Goering. 1989. Quantifying diesel injector coking with computer vision. Transactions of the ASAE 32(5): 1503-1506.

[24] Schoedder, C. 1981.Rapeseed oil as an alternative fuel for agriculture. Beyond the Energy Crisis -- Opportunity and Challenge Volume III. Third International Conference on Energy Use Management. Berlin (West). Eds. R. A. Fazzolare and C. R. Smith, 1815-22. Pergamon Press, Oxford.

[25] Auld, D. L., B. L. Bettis, and C. L. Peterson. 1982. Production and fuel characteristics of vegetable oilseed crops in the Pacific Northwest Vegetable Oil Fuels: Proceedings of the International Conference on Plant and Vegetable Oils Fuels. St. Joseph, MI: ASAE.

[26] Bettis, B. L., C. L. Peterson, D. L. Auld, D. J. Driscoll, and E. D. Peterson. 1982. Fuel characteristics of vegetable oil from oilseed crops in the Pacific Northwest. Agronomy Journal, 74(March/April): 335-39.

[27] Pryde, E. H. 1982. Vegetable oil fuel standards. Vegetable Oil Fuels: Proceedings of the International Conference on Plant and Vegetable Oils Fuels. St. Joseph, MI: ASAE.

[28] Engler, C. R., L. A. Johnson, W. A. Lepori, and C. M. Yarbough. 1983. Effects of processing and chemical characteristics of plant oils on performance of an indirect injection diesel engine. J. Am. Oil Chem. Soc., 60(8): 1592-6.

[29] Pryor, R. W., M. A. Hanna, J. L. Schinstock, and L. L. Bashford. 1983. Soybean oil fuel in a small diesel engine. Transactions of the ASAE 26(2): 333-337.

[30] Quick, G. R. 1980. Developments in use of vegetable oils as fuel for diesel engines. ASAE Paper Number 80-1525. St. Joseph, MI: ASAE.

[31] S.K. Haldar, B.B. Ghosh, and A. Nag, Studies on the comparison of performance and emission characteristics of a diesel engine using three degummed non-edible vegetable oils, Biomass and Bioenergy Volume 33, Issue 8, August (2009), Pages 1013-1018.

[32] Venkatesan.M., Performance and emission characteristics of Jatropha biodiesel in dual fuel mode with CNG in a single cylinder four stroke diesel engine".

[33] S. Naga Sarada, G. Sudha Rani, M.V.S.Murali Krishna, K. Kalyani Radha, Investigations on performance and emissions of a low heat rejection diesel engine with carbureted methanol and crude Jatropha oil as alternate fuels , International Conference On IC Engines(ICONICE),Dec 6- 9,(2007)PP:640-643.

[34] A.siva Kumar, Dr. D.maheswar & Dr. K.vijaya Kumar reddy, comparision of performance parameters by using jatropha and fish oil as biodiesel, International Conference On IC Engines (ICONICE), Dec 6-9, (2007), PP:617-619.

[35] V.Edwin Geo, C.Prabhu, B.Nagalingam and G.Nagarajan, Experimental Investigations to Improve the Performance, Combustion and Emission Characteristics of a Diesel Engine Using Preheated Rubber Seed Oil, International Conference On IC Engines(ICONICE),Dec 6-9,(2007) PP:12129.

[36] Deepak Agarwal and Avinash Kumar Agarwal; Performance and emissions characteristics of Jatropha oil (Preheated and blends) in a direct injection compression ignition engine; Applied Thermal Engineering, Vol. 27, pp 2314–2323, 2007

[37] Godiganur Sharanappa, Rana Prathap Reddy, Ch. Suryanarayana Murthy , Study on the performance and exhaust emissions of a diesel engine using preheated Mahua oil and its blends as fuel. International Conference On IC Engines(ICONICE),Dec 6-9,(2007), PP:1-9.

[38] O.M.I. Nwafor , Emission characteristics of diesel engine running on vegetable Pramanik K. 2003. Properties and use of Jatropha curcas oil and diesel fuel blends in compression ignition engine. Renewable Energy. 28: 239-48.

[39] C.M.Vara Prasad and A.V. Sita Rama Raju, Performance of High Grade Low Heat Rejection Diesel Engine with Crude Pongamia Oil, International Conference on IC Engines (ICONICE), Dec 6-9, (2007), PP: 40-643.

[40] Wilson Parawira, Biodiesel production from Jatropha curcas: A review. Scientific Research and Essays Vol. 5(14), pp. 1796-1808, 18 July, 2010 http://www.academicjournals.org/SRE ISSN 1992-2248 ©2010 Academic Journals.

[41] r.S.V.Channapattana Dr.R.R.Kulkarni, Bio-diesel asa fuel in I.C. engines – A review International Journal Of Computer Science And Applications Vol. 2, No. 1, April / May 2009 ISSN: 0974-1003.