Rubber Seed Oil as an Alternative Fuel for CI Engine: Review

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ABSTRACT

The large increase in number of automobiles in recent years has resulted in great demand for petroleum products. With crude oil reserves estimated to last only for few decades. Many countries import more crude oil causes huge foreign exchange out-go on the one hand and increasing exhaust emission on the other. Therefore there has been an active search for alternate fuels like biodiesel to provide a suitable diesel substitute for internal combustion engines. The Rubber seed oil based biodiesel offer a very promising alternative to diesel.Rubber Seed oil can become successfully alternate diesel fuel and help in decreasing the import of the crude oil used in diesel engine. This review has been taken up to identify the performance and emission using Rubber Seed oil biodiesel.

KEYWORDS:*Rubber Seed oil, performance, combustion, blends, CI engine, emissions.*

I. INTRODUCTION

The rubber seed cultivation in India is abundantly done and the availability of rubber seeds is also high. The oil obtained by crushing these seeds can be used as an alternate fuel and they are also non edible. Due to the high FFA content of the oil esterification is done before using it as alternate fuel. The emission characteristics and engine performance are acceptable. Also due to the high availability of rubber seed oil the impact of fossil fuel on Indian economy can be minimized. If mass production of oil is done, it will favor the agricultural sector of our country. Alternate fuels should be easily available at low cost, be environment friendly and fulfill energy security needs without sacrificing engines operational performance. For the developing countries, fuels of bio-origin provide a feasible solution to the twin crises of fossil fuel depletion and environmental degradation. Now biofuels are getting a renewed attention because of global stress on reduction of greenhouse gases (GHGs) and clean development - mechanism (CDM). The fuels of bio-origin may be alcohol, vegetable oils, biomass and biogas. Some of the fuels can be used directly while others need to be formulated to bring the relevant properties close to the conventional fuels. For diesel engines, a significant research has been directed towards using vegetable oils and their derivatives as fuels. Diesel engines are the most efficient prime movers. From the point of view of protecting global environment and concerns for long - term energy security, it becomes necessary to develop alternative fuels with properties comparable to petroleum based fuels. Unlike rest of the world, India's demand for diesel fuel is roughly six times of gasoline hence seeking alternative to mineral diesel is a natural choice. Rubber seed oils have comparable energy density, cetane number, heat of vaporization and stoichiometric air / fuel ratio with mineral diesel. In addition they are bio degradable, non-toxic and have a potential to significantly reduce pollution. Rubber seed oil and its derivatives in diesel engines, lead to substantial reductions in emissions of sulfur dioxides, carbon monoxide (CO), poly aromatic hydrocarbon (PAH), smoke, particulate matter (PM) and noise. Furthermore, contribution of biofuels to greenhouse effect is insignificant, since carbon dioxide (CO_2) emitted during combustion is recycled inphotosynthesis process in plants.

Fig-1: Photograph of Rubber plantation in Kerala along with Rubber seed

A. TRANSESTERIFICATION REACTION

It is most commonly used and important method to reduce the viscosity of vegetable oils. In this process triglyceride reacts with three molecules of alcohol in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and glycerol. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called esterification.

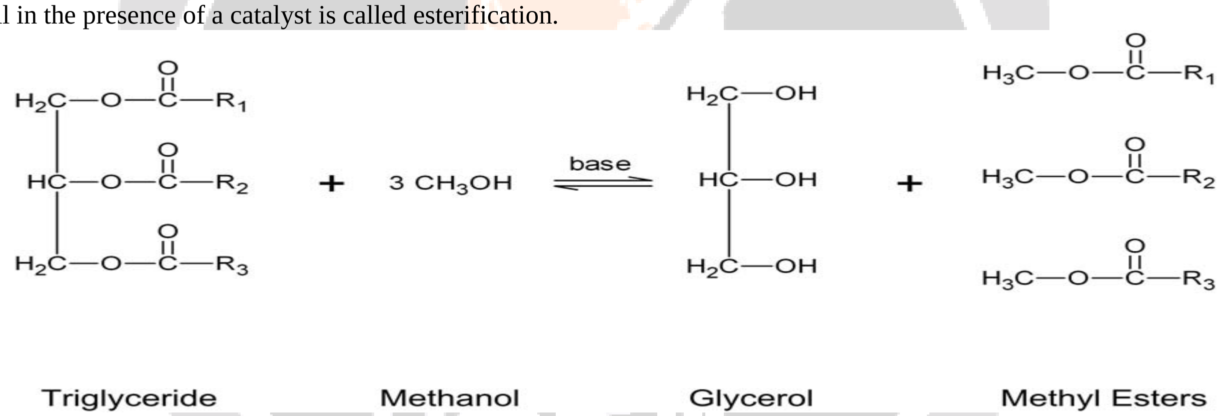

Fig-2: Transesterification reaction

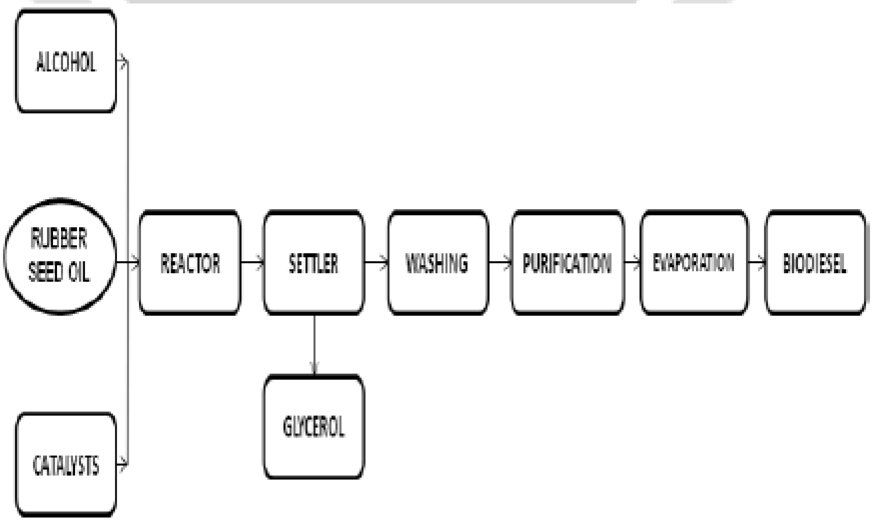

Fig-3: Process of Transesterification

B. PROPERTIES OF FUELS

Properties	Diesel	Rubber Seed Biodiesel
Density (kg/m³)	824 – 850	843 – 864
Kinematic viscosity at 40˚C (cSt)	2.51 – 4.59	3.78 – 5.81
Flash point (ºC)	50 – 75	71 – 148
Fire point (ºC)	57 – 81	158 – 167
Calorific value (MJ/kg)	42 – 43.2	36.5 – 39.86

Table-1: Properties of fuels

II. LITERATURE REVIEW

1. S. Senthil Kumar, K. Purushothaman [1]

Conducted experiments on, high FFA Rubber Seed oil as an alternative fuel for diesel engine. In this work, the use of blends of Rubber seed oil based biodiesel on performance and emission characteristics of a diesel engine compared to that of diesel was carried out.

Results showed that, the brake specific fuel consumption of B00 was lower compared with both B5 and B100 biodiesel. The percentage differences of thermal efficiency for B100 and B5 compared with diesel fuel were -9.66 and -3.68% respectively. A significant drop in efficiency was found with pure biodiesel when compared with diesel. Total hydrocarbon (THC) emissions increased for all fuels as the load increased. The percentage differences of THC emission for B100 and B5 compared with diesel fuel were 27.78% and -13.89% respectively. B100 produced the highest THC emission. B5 fuel produced lower THC emission than diesel fuel. The percentage differences of CO emission for B100 and B5 compared with diesel fuel were 20.83% and -12.50% respectively. B5 produced less CO emission than B00 under all load conditions.

2. SundaramArvind Narayan, SuthaShobana [2]

Conducted experiments on,characteristics and thermal efficiency of biofuels: Rubber Seed oil as a renewable energy source. In this work, the fuel characteristics and thermal efficiency of biodiesel (BD100), diesel (BD00) and a blend of five percent biodiesel (BBD5) by volume of diesel were studied with their performance and the emissions of blend of five percent biodiesel (BBD5) which was comparable to diesel.

Results showed that, the BSFC of diesel (BD00) was lower than other blends. There was a significant fall in thermal efficiency was found with BD100 when compared to BD00. A largest reduction was found for BD5 followed by BD100 and BD00 respectively after the endurance test.

3. S. Senthil Kumar, K. Purushothaman, P. K. Devan [3]

Conducted experiments on, performance and emission characteristics of a diesel engine using Rubber Seed oil and its diesel blends. In this work,the blends were prepared in the proportion of 25%, 50% and 75% rubber seed oil with diesel fuel.

Results showed that, the maximum BTE obtained for diesel, B25, B50, B75 and B100 was 28.64%, 27.74%, 26.82% and 26.2% respectively and with diesel it was 29.92% with full load. The BTE of B25 was 4% lesser and 7% higher than diesel and 100% RSO respectively at full load. The BSEC for B25, B50, B75 and B100 was 12.9 MJ/kW-hr, 13.24 MJ/kW-hr, 13.62 MJ/kW-hr and 14.0MJ/kW-hr respectively, whereas for diesel it was 12.4 MJ/kWh at full load.The EGT was increased with the increase in engine loading and also the concentrations of RSO in diesel blends. At maximum power output exhaust gas temperature with neat RSO was and for diesel it was 352°C. The maximum exhaust gas temperature of B25, B50, B75 and B100 was 365°C, 386°C, 394°C and 420°C respectively at full load. The B25 blend having lower exhaust gas temperature at full load compared to all RSO - diesel blends. The CO emission was increased with an increase in proportion of RSO and its diesel blends at all loads. The CO emission with diesel and B25 and B100 were 3.44 g/kW-hr and 4.64 g/kW-hr respectively and for diesel it was 2.95 g/kW-hr at full load. The CO emission increases with increase in the concentration of RSO in the diesel fuel. It was observed that there was 70% decrease in CO emission for B25 blend compared with B100 at full load and it produces 17% higher CO emission than diesel fuel.The HC emission also increases with the increase in loading and increase in percentage of RSO in the diesel blend. At maximum power output the

HC emission for B25 and B100 were 0.59 g/kW-hr and 0.68 g/kW-hr respectively and for diesel was 0.55 g/kW-h at full load.The B25 blend results in an acceptable drop in HC emissions of 0.3 g/kW-hr at full load, which was lower compared to neat RSO. The NO emission for the B25, 100% RSO operation was 10.2 g/kW-hr and 6.5 g/kW-hr respectively and for diesel it was 11 g/kW-hr at full load.The NO emission of B25 was decreased by 7% compared with diesel fuel.At maximum power output, the smoke density was 4.4 BSU and 6 BSU with B25 and 100% RSO and 3.4 BSU with diesel. Smoke level increases by increasing the percentage of RSO with diesel fuel. The B25 blend reduces the smoke level from 6 BSU to 4.4 BSU at full load.

4. KulachatePianthong, PrachasantiThaiyasuit [4]

Conducted experiments on, production of biodiesel from Rubber Seed oil and its effects to engine performances. In this work, methyl ester from rubber seed oil blended with diesel by mass ratio of 10% methyl ester (B10), 25% methyl ester (B25), 100% methyl ester (neat or B100), and diesel was carried out.

Results showed that, the torque of the engine using B100 was averagely about 5% lower than that of diesel. The torque has tendency to increase with increasing in engine speed and its maximum was at 1900 rpm. The BSFC tends to decrease with increasing in engine speed. The B100 engine consumes more fuel than diesel engine averagely around 10% at various speeds. The trends of brake thermal efficiency of all fuels were found to increase when increasing in engine speed. At low engine speed (1300-1700 rpm), the B100 engine provides the highest thermal efficiency and about 5% higher than that of diesel. The B10 and B25 give much closed brake thermal efficiency to the diesel. Trends of CO specific emission, in all of fuel tests, were found to decrease when increasing in engine speed. When engine speed more than 2000 rpm, the CO specific emission of the B100 engine rises and gets higher than that of diesel engine. The B10 and B25 give the CO_2 and CO specific emission in between B100 and diesel. For the NO_X specific emission, all of fuel engine tests were found to decrease when engine speed was increased. The NO_X specific emission of methyl ester at 1300-1900 rpm was the highest.

5. S. N. Harikrishnan, R. Sabarish [5]

Conducted experiments on, direct injection diesel engine using Rubber Seed oil. In this work, the performance and emission characteristics of single cylinder four stroke direct injection diesel engine using rubber seed oil (RSO) as an alternate fuel is evaluated.

Results showed that, with increasing brake power, the brake thermal efficiency of the blends was increased. In the case of 75:25 (rubber seed oil: diesel) blend, the highest thermal efficiency was observed. Brake thermal efficiency of 50:50 blend closely matches that of diesel oil. Blends in the range of 25%R of rubber seed oil resulted in similar exhaust gas temperature values to that of the diesel. Smoke increases with increasing load in all cases. The highest value of smoke observed was 25%R, was found to closely match that of diesel. P-theta diagram of 100%R was not similar to other blends and of diesel. The performance of 100%R was inferior in all load conditions compared to other fuels. The P-theta diagram of 25%R was almost similar to that of Diesel with marginal difference in cylinder pressure. The peak pressure values of 25%, 50%, 75% were 73,73,72 bars respectively.The highest peak pressure was obtained with 25%, 50% blend compared to other fuels. All the net heat release rate of almost all the blends were similar to diesel operation with marginal difference in heat release rate.

6. N. Ravichandran, R. Senthil, R. Silambarasan, K. Veeramanikandan, G. Pranesh [6]

Conducted experiments on, performance and emission characteristics of blending Di-ethyl Ether in Rubber Seed vegetable oil using a single-cylinder diesel engine. In this work, experimental results on dual fuel operation of a single cylinder diesel engine with diesel, Rubber Seed and mixture of Rubber Seed oil and diethyl ether (DEE) as primary fuels.

Results showed that, there was a steady rise in brake thermal efficiency as the load increases. B20 fuelled operation resulted in higher brake thermal efficiency. There was a steady decreases in BSFC as the load increases. The BSFC will slightly lower than the diesel fuel.

7. P. L. Navaneethakrishnan, T. Mukesh, K. Hariprakasham [7]

Conducted experiments on, performance & emission characteristics of methyl ester from Rubber Seed oil in a CI engine. In this work, biodiesel from Rubber seed oil has been investigated in a constant speed CI diesel engine with varied fuel injection pressures (160, 180 and 200 bar).

Results showed that, the specific fuel consumption has decreased with increase in injection pressure till 180bar and increases when pressure was increased. The lowest SFC was recorded for B10 at 180 bar injection pressure. The SFC for B10 blend was 0.2158 kg/kW-hr. Increase in injection pressure from 160 to 200 bar leads to reduction in SFC and at 200 bar injection pressure SFC has increased. The maximum efficiency obtained for B10 blend at 180bar injection pressure. At this pressure the maximum efficiency was obtained as 37.49% at full load condition. Brake thermal efficiency of B10 blend at 160 bar was 33.01%, with increase in injection pressure to 180 bar, the brake thermal efficiency for above said blend was improved by 4.4%. Mechanical Efficiency of B50 and other biodiesel blends were less than diesel. For all blends of rubber seed oil at injection pressure of 180 bar, NO emission was lower. The higher NO at injection pressure other than 180 bar was result of higher exhaust temperature. NO emissions were higher for B50 than that for other blends. For all blends of rubber seed oil at injection pressure of 180 bar was lower. B10 emits very low level of CO_2 but with higher concentration of biodiesel in blend. The higher smoke opacity was recorded at higher injection pressure (200 bar).

8. Dr. HiregoudarYerrennagoudaru, Chandragowda M, Manjunatha K, NagarajBasavantappaHugar [8]

Conducted experiments on, multi cylinder diesel engine using Rubber Seed oil and diesel. In this work, the study of performance and emission characteristics of a multi cylinder, constant speed diesel engine using rubber seed oil & compared with the diesel fuel was carried out.

Results showed that, the CO level decreases when rubber seed oil as a fuel for conventional and modified engine. As load increases brake thermal efficiency was also increases for diesel as well as rubber seed oil. As the load increases specific fuel consumption decreases for different loads and the SFC of rubber seed oil was less than the diesel. There was an increase in Hydrocarbon emission for diesel fuel and decreases for rubber seed oil in both conventional and modified engine.

9. TaufeequrRahman, Prakash S Patil, OmprakashHebbal [9]

Conducted experiments on, performance and combustion characteristics of Rubber Seed biodiesel and its blends on diesel engine and LHR engine. In this work, various proportions of rubber seed and diesel (B25, B50, B75 and B100) were prepared by transesterification process on volume basis and used as fuels in a four stroke single cylinder direct injection diesel engine to study the performance and emission characteristics of these fuels and compared with neat diesel fuel.

Results showed that, R25 with LHR has higher brake thermal efficiency than normal engine D100. The maximum efficiency obtained in the case of LHR engine fueled with (R25) biodiesel at full load was higher by about 2.42% than LHR engine fueled with diesel. The thermal efficiency obtained in the case of LHR engine fueled with biodiesel was substantially good enough within the power output range of the test engine.The mechanical efficiency of diesel was slightly higher than the rubber seed biodiesel in case of normal engine. With increase in the concentration of rubber seed biodiesel in diesel decreases the mechanical efficiency. At full load D100 and R25 in LHR has maximum efficiency of 86% and 80% respectively which were 5.1% and 4.7% higher than D100 and R25 of normal engine. The specific fuel consumptions decreased with the increase of brake power. At maximum load the specific fuel consumption of LHR engine fueled with biodiesel was higher than LHR engine fueled with diesel and lower than normal engine fueled with diesel and biodiesel. Indicated mean effective pressure was low for rubber seed oil methyl ester compared to diesel. By using thermal barrier coating there was slight increase in indicated mean effective pressure as compared to normal engine. As the load increases the mean pressure of an engine increases. Air fuel ratio decreases with increase in load. The exhaust gas temperature increases with the increase of the brake power. At full load, the exhaust gas temperature of LHR engine fueled with biodiesel gives lower value by about 2.32% than LHR engine fueled with diesel and higher by about 2.73% and 6.53% respectively than conventional engine with diesel and biodiesel. There was no much difference in volumetric efficiency with each load. Volumetric efficiency for NE-D100 was slightly higher than the LHR-D100. Efficiency for NE-R25 and LHR-R25 were almost similar. The cylinder pressure in the case of biodiesel fueled LHR engine was about 4.7% lesser than the diesel fueled LHR engine and higher by about 1.64% and 12.22% than conventional engine fueled with diesel and biodiesel. The maximum pressure obtained for LHR engine fueled with biodiesel was closer with TDC around 2 degree crank angle than LHR engine fueled with diesel. The maximum heat release of LHR engine with biodiesel was lower about 9.1% than LHR engine fueled with diesel and higher about 3.2% and 7.8% respectively than conventional engine fueled with diesel and biodiesel.

III. CONCLUSION

Rubber Seed biodiesel satisfies the important fuel properties as per ASTM specification of biodiesel. Engine works smoothly on Rubber Seed oil methyl ester with performance compared to diesel operation. The Rubber Seed biodiesel can be successfully substituted as alternative fuel for CI engine.

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