Biodiesel Production From Rubber Seed Oil And Testing In A Twin Cylinder Direct Injection Diesel Engine

Biju Cherian Abraham[1], Georgekutty S Mangalathu[2], Dr. Shajan Kuriakose [3]
Assistant Professor [1], Assistant Professor [2], Professor [3], Mechanical Engineering Department, Mar Athanasious College of Engineering, Kothamangalam, Kerala, India.

Abstract

A domestically produced, renewable fuel called biodiesel is better for the engine and offers economic, energy security, fuel quality, and environmental benefits compared to petroleum-based diesel. Biodiesel can be manufactured with the existing technology called transesterification and a blend of 20 percent biodiesel and 80 percent petroleum diesel (B20) is used in conventional diesel engines. For these reasons, it provides an immediate opportunity to begin reducing our dependence on conventional petroleum fuel. In this paper the production of rubber seed oil from its kernels and there after its conversion to biodiesel and its performance analysis in a twin cylinder diesel engine are conducted. Marginal improvement in mechanical efficiency and brake thermal efficiency is observed during the testing.

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1. Introduction

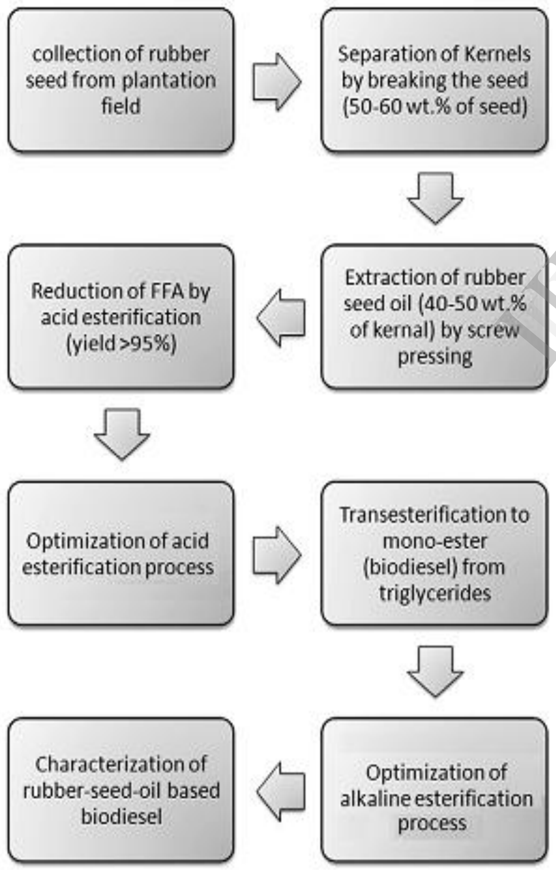
Biodiesel is one of the alternative fuels usable in any conventional diesel engine with a little or no modification to the engine or fuel system. Increased utilization of renewable biofuels results in significant micro-economic benefits to both the urban and rural sectors. Also it results in a substantial reduction of unburned hydrocarbons, carbon monoxide and particulate matter. A renewable fuel can be derived from vegetable oils, used oils and animal fats. Biodiesel is not the same thing as raw vegetable oil; rather, it is produced by a chemical process which removes the glycerin and converts the oil into methyl esters. Biodiesel can be used in any concentration with petroleum- based diesel fuel with little or no modification to existing diesel engines. These blended fuels are referred to as “biodiesel blends”, and include the percentage of biodiesel in the blend, such as B2 (2%), B5 (5%) or B20 (20%). Dilution or blending as well as heating of vegetable oils reduce the viscosity. Different methods for reducing viscosity have been analyzed for locally available [1,3] bio-fuels and found that dilution is the economic way for reducing the viscosity and improving their combustion properties. Experimental investigations revealed that local fuels such as coconut, palm and rubber seed oils are found to be alternative fuels to diesel in compression ignition engine[2]. These oils can be used directly without any major modifications in the compression ignition engines[5]. The aim of this paper is to study the suitability of locally available vegetable oil based biofuels in Kerala such as coconut, palm and rubber seed oils as substitutes to conventional diesel fuel in diesel engines. Studies conducted by various researchers revealed that blends of 10-50% of coconut, palm and rubber seed raw oils with diesel can be used directly without modifying the engine and without much operational difficulty [4]. To encourage its use, most major diesel engine manufacturers have affirmed that using B20 in their equipment will not void their warranties[6]. Here we have studied the production of rubber seed oil from its kernels and its conversion to biodiesel and its performance in a twin cylinder diesel engine.

2. Production of biodiesel

Rubber seeds are collected and kernels are separated by breaking them. These kernels are crushed and oil is extracted by screw pressing and then filtered. The rubber seed cake, which is the left over after oil extraction is rich in protein and can be used as cattle and poultry feed. The rubber seed oil varies in colour from light yellow to brown, depending on the Free Fatty Acids (FFA) content, yellow being on the lower side. Rubber seed oil extracted and used for this analysis had an acid value of 35 mg KOH/g, which is equivalent to 17.5% FFA. The presence of high FFA hinders the transesterification process by single stage using a base catalyst due to its preference for saponification thereby forming soap. Hence the amount of FFA must be reduced to its minimum by acid esterification before alkaline esterification.

Processing of Rubberseed Oil

Transesterification is the chemical reaction between triglyceride (rubber seed oil) and alcohol to produce monoester triglyceride which is transformed into monoester and glycerin. This monoester can be separated and blend with diesel or used directly with no major modification in IC engines. In the case of rubberseed oil the estrification consists of acid and alkaline transestrification process. The chemical reaction of the esterification process is given below:



Block diagram of the entire process

Acid and Alkaline estrification process

The objective of the first stage, i.e. acid esterification process, is to reduce the acid value of the raw rubber seed oil from 35 mg KOH/g to less than 4 mg KOH/g. Acid Number (AN) is the measure of acid concentration in a nonaqueous solution. It is determined by the amount of potassium hydroxide (KOH) base required to neutralize the acid in one gram of an oil sample. The standard unit of measure is mg KOH/g. In Acid esterification the firsts step reduces the FFA value of crude rubber seed oil to about 2% using acid catalyst 920 g of raw rubber seed oil was taken and mixed with 200 ml of methanol along with 6 ml sulphuric acid in a 2 liter biodiesel plant for the acid esterification process. The oil is heated to about 50°C. along with stirring for 20–30 min. It is then transferred to a settling funnel and after 10 to 15 hrs, the excess acid and impurities settle at the top and are removed from the oil. After removing the impurities after acid estrification the remaining oil is again heated to about 50°C again and 5 gm of NaOH is dissolved in 300 ml methanol and is poured into the bio diesel plant and the mixture is heated and stirred for 30 min. The reaction is stopped, and the products are allowed to separate into two layers. The lower layer contained impurities and glycerol and the ester remains in the upper layer. Lower layer is discarded and yellow colour upper layer known as biodiesel is separated. Methyl esters are then washed to remove the entrained impurities and glycerol and again heated to about 85°C for 15 minutes to remove the moisture content in the biodiesel.

Equipment used for transesterification process

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Engine details and testing

Twin cylinder four stroke diesel engine, make – Kirloskar , Brake power-7.36 KW, Speed-1500rpm, Stroke -110mm, Bore -80mm

Performance test was conducted on the four stroke twin cylinder engine using ordinary diesel and biodiesel (B 20) and the following tables were obtained.

Table 1. Conventional diesel test results

Sl. No	Load kg	Time for 10 cc fuel consumption sec	BP Watts	IP Watts	TFC kg/hr	Mechanical Efficiency %	Indicated Thermal Efficiency %	SFC kg/Whr
1	0	38.1	0	2650	0.78	0	25.39	0
2	2	29	1107	3607	1.03	30.69	27.88	0.000931
3	5.5	24	3044.3	5544.3	1.25	54.91	35.47	0.000409
4	8	19	4428	6928	1.57	63.92	35.09	0.000355
5	10.5	14.1	5811.8	8311.8	2.12	69.92	31.24	0.000365
6	13.5	10	7472.3	9972.3	2.99	74.93	26.58	0.000415

Frictional Power = 2500 watts

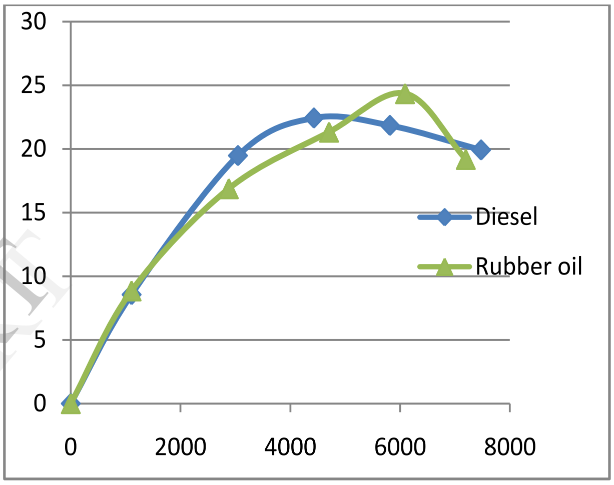
Table 2. Biodiesel (B 20) test results

Sl. No	Load kg	Time for 10 cc fuel consumption sec	BP Watts	IP Watts	TFC kg/hr	Mechanical Efficiency %	Indicated Thermal Efficiency %	SFC kg/hr
1	0	39	0	2650	0.77	0	22.36	0
2	2	30	1107	3257.01	1.00	33.99	26.04	0.0009
3	5.2	22	2878.23	5028.23	1.36	57.24	29.49	0.000472
4	8.5	17	4704.71	6854.80	1.76	68.64	31.06	0.000374
5	11	15	6088.56	8238.56	1.99	73.90	32.94	0.000327
6	13	10	7195.57	9345.57	2.99	76.99	24.91	0.000415

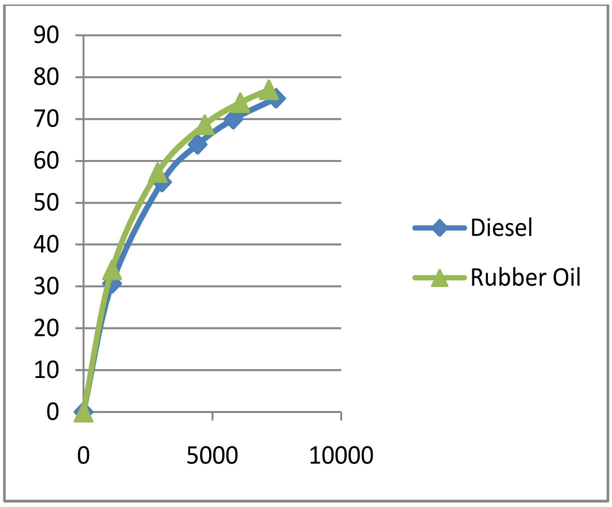
Frictional Power = 2150 watts

Results and Discussions

From the observations, the data for conventional diesel and biodiesel were obtained and compared. With the help of these data, the characteristic curves were plotted and compared. The graph brake power vs brake thermal efficiency shows higher brake thermal efficiency than conventional diesel for B20 at brake power of 6000Watts range. Brake thermal efficiency shows a tendency to increase with increase in load. This is due to the reduction in heat loss and is leading to the increase in output power. The mixing of biodiesel with diesel oil yields to high thermal efficiency curves. The thermal efficiency of the engine is improved with increasing concentration of the biodiesel in the blend. The reason may be the additional lubricating effect shown by the rubber seed oil and the biodiesel. Also the molecules of biodiesel (i.e. methyl esters of the oil) contain some amount of oxygen, which takes part in the combustion process. The graph of SFC with brake power shows a variation in SFC which goes on decreasing with increase in brake power. It falls to a value of 0.000327 kg/W hr and then increases. Brake specific fuel consumption is found to decrease with increase in the load.



Graph of BP vs. Brake Thermal Efficiency



Graph of Brake power vs. Mechanical efficiency

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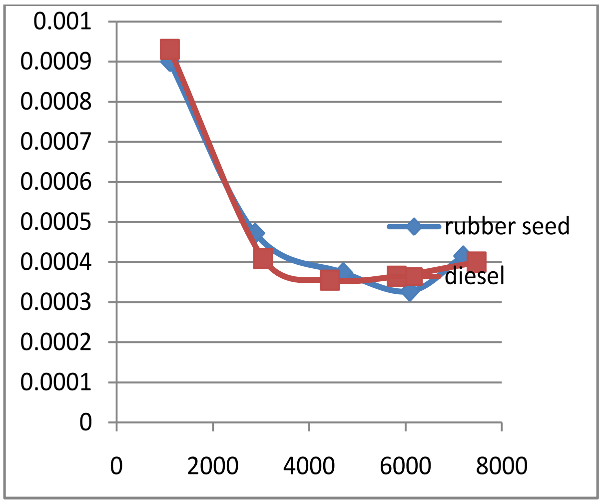

Graph of Brake power vs. SFC

Conclusion

Biodiesel blends were tested in a diesel engine and performance characteristics were analysed. By analyzing the results of all experiments it can be concluded that methyl esters of rubber seed oil can be used in compression ignition engine without much change in the engine hardware. Engine performance with biodiesel does not differ greatly with that of the diesel. But a little power loss along with higher specific fuel consumption is observed. This is due to the low calorific value of biodiesel. Brake thermal efficiency and mechanical efficiency are found to be increasing, which may be assumed to be due to the lubricating effect of rubber seed oil. But in view of the petroleum fuel shortage biodiesel can be certainly considered as a potential fuel extender. Use of the biodiesel as partial diesel substitute can boost the farm economy, reduce uncertainty of fuel availability. Also from literatures it is observed that its use helps in controlling air pollution to a great extent.

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References

1. Eka, H. D., Tajul Aris, Y. and Wan Nadiah, W. A, \\(2010), *Potential use of Malaysian rubber (Hevea brasiliensis) seed as food, feed and biofuel*, International Food Research Journal 17: 527-534.

2. Piyanuch Nakpong, Sasiwimol Wootthi-kanokkhan, (2009)- *Biodiesel production from mixtures of vegetable oil and used cooking oil*, Asian Journal on. Energy and Environment, 10(04), 221-229.

3. A.S. Ramadhas, S. Jayaraj, C. Muraleedharan-2004- *Biodiesel production from high FFA rubber seed oil, Fuel 84, 335–340*

4. Houfang Lu, Yingying Liu, Hui Zhou, Ying Yang, Mingyan Chen, Bin Liang, 2008.- *Production of biodiesel from Jatropha curcas oil.*

5. Lin Lin a, Zhou Cunshan b, Saritporn Vittayapadung c, Shen Xiangqian d, Dong Mingdong *–(2010) Opportunities and challenges for biodiesel fuel.*

6. Canakci M and Gerpen J.V. 2001. *Biodiesel production from oils and fats with high free fatty acids,ASAE44(6):429-36.*