EFFECTS OF USING PONGAMIA, NEEM AND RICEBRAN METHYL ESTERS IN A CI ENGINE

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Abstract: The area of biodiesel production has gained its significance recently due to the present day scenario of shortage of conventional fuel and environmental concerns. In this paper potentiality of using Pongamia Methyl Ester (POME), Neem Methyl Ester (NOME) and Rice Bran Methyl Ester (ROME) as renewable and alternate fuel for conventional CI engines is studied. Transesterification process is used to produce POME, NOME and ROME from raw oils and investigations were done to test the performance and emission characteristics of biodiesel over conventional diesel fuel. The tests were carried out in a single cylinder direct injection diesel fuelled engine at varying loads. A significant reduction in engine emissions up to 33% is observed for POME than diesel (CO, HC, NOx) is noticed by the use of biodiesel while the performance remaining almost similar. Results indicated that POME has an efficiency of 26.8% compared to 27.19% which is higher than the other two oils. The reduction in efficiency is due to the higher viscosity and low atomization of B100 when compared to diesel.

Keywords:Biodiesel, Methyl Esters, Transesterification, Performance, Emission

I. INTRODUCTION

The growth and development in the agricultural and industrial sectors of the world nations for the past 10 years has been very rapid and enormous. Due to this there is an imbalance between demand and supply of energy. Energy generated from conventional fuels has become an acute problem because the resources are fast depleting. With increased number of automobiles the emissions from the engine has also become a serious problem for both humans and environment. It was in this context the idea of biodiesel got its significance although it was not a new one. Rudolph Diesel, the inventor of CI engine, primarily came up with the idea of using straight vegetable oil (peanut oil) as fuel in 1910. But later with cheap availability of crude oil diesel became more popular. Vegetable oils have very similar physical and chemical properties when compared to that of diesel fuel which make them a promising alternative for conventional fuels. The greatest advantage of vegetable oil is that they are renewable and eco-friendly. Biodiesel is basically extracted from vegetable or animal fats, any fuel which is 100% pure in composition that meets the requirements of American Society for Testing and Materials (ASTM) for biodiesel in their D 6751 standard can be called as a biodiesel. Biodiesels offers many other benefits such as minimal sulphur and aromatic content, higher flash point, lubricity, cetane number, biodegradable and non-toxicity. On the other hand they have the disadvantages like higher viscosity, low calorific value, low volatility and oxidation stability. There has been a lot of researches done on different edible and non-edible vegetable oils and their biodiesels such as sunflower, peanut, soybean, cottonseed, rapeseed, jatropha etc. But in India, non-edible oil plants such as Jatropha, Pongamia, Neem, Mahua are found abundantly. Out of these plants, Jatropha and Pongamia have shown good promise for biodiesel production. Since the Pongamia Pinnata plant is available in large amounts in tropic regions of India, the study and investigation of performance and emissions of engine using this oil is necessary. Pongamia oil is non-edible oil and can grow literally in any vegetation which makes it superior than other oils available. From previous studies, it was found that the vegetable oils can be used directly in CI engines effectively without any modifications. But it poses problems in the long run due to high viscosity and low volatility so it is necessary to reduce the viscosity of these by using methods such as preheating, blending, transesterification, etc. to utilize them effectively as an alternative to diesel in the conventional CI engines without any major modifications. Preheating of the oil showed an increase in the thermal efficiency of engine in using cottonseed oil. The improvement in volatility of mixture by preheating is important in improving the fuel evaporation resulting smoke reduction. Out of the above mentioned techniques transesterification is the best and cheapest method for biodiesel production. A significant improvement in the engine performance and emission characteristics was observed while using transesterified biodiesel when compared to diesel fuelled engine. Thermal efficiency of the engine was improved while brake specific fuel consumption reduced and a considerable reduction in the exhaust smoke opacity was observed. But the CO and HC are increased with retarding the injection timing and it decreases with advancing the injection timing. In this present study methyl esters of Pongamia, Neem and Rice Bran oils were produced using transesterification process and tests were conducted to determine their performance in a single cylinder diesel engine.
II. MATERIALS AND METHODS

Transesterification: It is a process of transforming the long branched triglyceride molecules of straight vegetable oil into smaller straight chain molecules which has a structure compatible to that of diesel. The methyl ester formation by transesterification reaction depends on many parameters such as reaction temperature, concentration of reactants, nature of catalysts, reaction time etc. This is an equilibrium reaction which requires more amount of alcohol to complete the reaction. The basic reaction is that the raw vegetable oil is allowed to react with alcohol in the presence of alkali catalyst to produce the methyl ester and glycerol as by-product Figure 1. The oil was introduced into the reaction vessel by heating it to the required temperature. To get maximum biodiesel output the parameters were optimized. It is found that maximum output is obtained when 0.2%wt of catalyst mixture was mixed with 150% excess alcohol and stirred well for 1 to 2 hours at constant temperature of 60 degree celsius. Then it is allowed to settle under gravity in separation funnel for 24 hours. Two distinct layers are formed in the funnel, top layer was of methyl ester and bottom layer was of glycerol. The biodiesel is separated out and washed with warm water to remove the catalyst.

III. EXPERIMENTAL SETUP

In this present work, a comparative study of Pongamia pinnata methyl ester, Neem oil methyl ester and Rice bran oil methyl ester with conventional diesel fuel was done. The methyl esters of the three oils were used in engine (B100). The tests were conducted in a 5 HP single cylinder water cooled compression ignition Kirloskar engine (Figure 2) at rated speed of 1500 rpm. Engine was electrically loaded with rheostat. Engine specifications are given in Table I.

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Engine was first run with diesel fuel for base readings and then with the blends of Pongamia, Neem and Rice bran oil and these were subjected to the performance and emission tests in the engine. Exhaust emissions from the engine were measured using the CRYPTON 290 EN2 Emission Analyser. The performance data were tabulated and analysed using parameters such as brake thermal efficiency, in cylinder pressure and emissions with HC, CO, CO₂.

IV. RESULTS AND DISCUSSION

Performance Analysis

The variation of brake thermal efficiency with brake power for POME, ROME and NOEE compared with diesel is shown in Figure 3. The brake thermal efficiency of POME (26.83%) is closer to that of diesel (27.19%). This is due to its high viscosity and poor mixture formation which leads to slow combustion of B100 of POME than that of diesel. The other two oils have higher viscosity and this leads to lower thermal efficiency. The maximum efficiency for NOME and ROME are 24.2% and 26.4% respectively.
The NOME and ROME results in lower peak pressure compared to POME and diesel on account of low combustion rate. The peak pressure in the case of NOME and ROME are 58 and 62 bar. It is because of the fuel accumulation during the ignition delay period causing problems in the premixed combustion period due to the high viscosity of the fuel. But the peak pressure for POME is 68 bar at rated power which is closer to that of diesel with 69 bar. This is because of higher viscosity of POME fuel resulting in strong fuel spray penetration thus improving the air-fuel mixing, better ignition quality and higher oxygen content helps in advancing of the combustion process compared to other oils.

**Emission Analysis**

Figure 5 shows the variation of carbon monoxide (CO) emission with brake power for POME, ROME, POME and diesel. NOME results in higher CO emission compared to other oils. The maximum CO emission noticed is 0.39 % vol for NOME whereas in diesel it is 0.32% vol. POME has got minimum emission with 0.21% vol. POME shows better emission characteristics when compared to that of diesel. This is due to the higher oxygen content in POME resulting in complete combustion of POME than diesel fuel.

The hydrocarbon emission at maximum load observed is 42 ppm for POME whereas in diesel it is 28 ppm this is due to higher cetane number of diesel.

Cetane number of the fuel plays a vital role in ignition process. Higher the cetane number, better the air-fuel mixing leading to low HC emission. It is clear from the fact that due to higher cetane number of diesel, it emits lower HC than biodiesel. For NOME and ROME the HC emission is 44 ppm and 80 ppm which is higher when compared to diesel, because cetane number of these oil are less which in turn increases the ignition lag causing poor combustion.

The adiabatic flame temperature, heat release during the combustion and peak pressure causes increase in NO\textsubscript{x} emission. The NO\textsubscript{x} emission for biodiesel of POME is 383 ppm making it a better fuel when compared to 441 ppm of diesel. The temperature and pressure are high for diesel combustion. NO\textsubscript{x} emission is lower for ROME (312 ppm) and NOME (385 ppm) compared to diesel because of low temperature and pressure during combustion.

**CONCLUSION**

The effects on engine performance, combustion and emission were studied. The following are the important inferences got while running the CI engine using Pongamia, Neem and Rice bran methyl esters.

- The methyl esters of Pongamia, Rice bran and Neem oil can be used directly in the CI engine without any modifications.
- The brake thermal efficiency of POME (26.83 %) is closer to that of diesel (27.14%) whereas it is lesser for rice bran and neem oil esters.
- The peak pressure for POME is 68 bar at rated power which is closer to that of diesel with 69 bar. When compared to neem and rice bran oils POME shows better ignition and combustion characteristics.
- NO\textsubscript{x} emission of POME (383 ppm) at full load is very much less compared to that of diesel (441 ppm) because of its low temperature and pressure during the combustion. The NO\textsubscript{x} emission of neem and rice bran oils are higher compared to Pongamia methyl ester.
- The emission levels of POME is almost 33 % lower than that of diesel making it a better substitute than neem oil and rice bran methyl esters.
- The HC and CO emissions are reduced by about 40 % and 32 % respectively in POME operation compared to diesel. Poor mixture formation and high viscosity of NOME and ROME results in higher HC and CO emission than POME.
From the tests it is found that better the formation of mixture, the better combustion and performance characteristics of the engine. The key factors which determine the mixture formation are density, viscosity and volatility of the fuel. This factor also helps in maintaining good emission characteristic during engine operation. Even though NOME and ROME can be used as a diesel substitute, POME gives better characteristics and is a promising alternative to the conventional diesel fuel.

REFERENCES


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