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Trans-esterification process for biodiesel production and performance of biodiesel based engines: A review

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ABSTRACT

The research work described in the present work aimed to predict effective method of biodiesel production from various edible and non-edible oils. The performance of these biodiesels in compression ignition engines is also studied on the basis of optimization techniques such as RSM, NSGA-II etc. It is observed that optimization techniques are the best way to predict the performance of biodiesels in compression ignition engines.

Keywords: Trans-esterification, Optimization techniques, response surface methodology, Non-dominating sorted genetic algorithm

INTRODUCTION AND RESEARCH STUDIES

The main cause of pollution in the atmosphere is due to the emission contents from the automobiles. Among these, diesel engines are vastly used in every field like agriculture, transport, Industries etc. Hence alternate fuel of diesel engine is found by many researchers with their methods of production. Few researchers [Dhingra et al., 2013a; Dhingra et al., 2013b; Dhingra et al., 2014a; Dhingra et al., 2014b; Dhingra et al., 2014c; Dhingra et al., 2014d; Dhingra et al., 2016; Lin and Kuo, 2013; Rahman et al., 2013] observed that biodiesel is the best alternative to run the compression ignition engines.

Leu (2013) prepared biodiesel from waste cooking oil through alkaline trans-esterification process and its performance analysis in a standard test engine was also investigated. The pretreatment step for the modulation of both acid number and iodine number is important for preparation of biodiesel. This technique was developed in Taiwan and tests were performed in a compression ignition engine in order to measure CO, NO_x and SO_x emissions. Reduction of 51 % in CO emissions, 73 % in SO_x emissions, 13 % in NO_x emissions and 10 % motion horse power while up to 11.3 % rise in fuel consumption were observed when engine was running at full load condition with blended biodiesel.

Liaquat et al. (2013) suggested CB5 (5 % coconut biodiesel in diesel) and CB15 (15 % coconut biodiesel in diesel) as an alternative fuel in a compression ignition engine without any modifications in the engine components. The performance and emission parameters were measured for three samples: DF (100 % diesel fuel), CB5 and CB15 respectively. The results revealed a considerable decrease in torque and brake power while increase in specific fuel consumption for biodiesel-diesel blended fuels over the speed range of 1500-2400 rpm compared to neat diesel. However lower HC, CO and, higher CO_2 and NO_x emissions were found for biodiesel-diesel blends in comparison to diesel. Also sound levels of both the blended fuels were significantly reduced.

Lin and Kuo (2013) produced tyre pyrolysis oil using pyrolysis in the temperature range of 673-873 K. The effects of injection timing on the performance and exhaust emissions of a four cylinder in-line diesel engine using diesel fuel, TP10 (10 % tyre pyrolosis oil in diesel) and TP20 (20 % tyre pyrolysis oil in diesel) were observed. Lower carbon monoxide and oxygen concentrations were found with advanced injection timing of 10°, 14° and 18° crank angle from top dead centre in all test situations than the identical injection timing. The results indicated that although delayed injection timing reduced the nitric oxide and oxygen emissions but increased the carbon monoxide emissions.

Mofijur et al. (2013) reviewed the various research works of biodiesel development, biodiesel feedstocks, biodiesel standards, and advantages and challenges of biodiesels. Also the impact of biodiesel on combustion characteristics, engine durability and materials compatibility was presented in order to replace the conventional diesel in compression ignition engines. He concluded a clean and environment friendly fuel called biodiesel having functional properties similar to diesel can be used to run the diesel engines.

Putrasari et al. (2013) experimentally investigated performance and emission characteristics of two cylinders DI diesel engine running on various ethanol-diesel blends (E2.5 %, E5 %, E7.5 % and E10 %) at different loads (0, 10, 20, 30, 40, 50 and 60 N-m). The results of the experiments revealed a significant increase in engine power and indicated mean effective pressure with increase in ethanol blends in diesel. An increase in lubricating oil temperature with slight decrease in both specific fuel consumption and exhaust gas temperature was also experienced when ethanol percentage in diesel was increased. Furthermore decreasing trends in emissions contents were seen with increase in the amount of ethanol in diesel. Hence ethanol blends up to 10 % were used as an alternative fuel in diesel engines to achieve the required objectives (performance and emission parameters).

Rahman et al. (2013) produced palm and calophyllum inophyllum based biodiesels through trans-esterification process. The fuel properties of produced biodiesels were compared with ASTM D6751 for further use in a diesel engine. It was concluded that both the biodiesels were the promising alternative fuels of diesel in compression ignition engine due to comparable physio-chemical properties as that of diesel. Also engine tests revealed that brake specific fuel consumption increased with increase in blending ratio of both the biodiesels. Further CO and HC emissions, and exhaust gas temperature were significantly reduced. However NO_x levels were higher with high levels of biodiesel-diesel blends. 20 % blending ratio of calophyllum biodiesel was suggested for low contents of CO and HC emissions.

Roy et al. (2013) experimentally prepared canola oil and waste canola oil based biodiesels by trans-esterification process. The measured fuel properties of produced biodiesels were compared with diesel, ASTM D6751 and testing methods. It was found that most of the properties of produced biodiesels were closer to biodiesel standards. To measure engine performance and emissions, authors also tested pure canola oil, waste canola biodiesel and pure canola biodiesel-diesel blends (from 2-20 % by volume) in a direct injection diesel engine. The results indicated similar fuel properties, almost same performance and emissions for pure canola oil and waste canola biodiesel blends. However significant reduction in HC and CO emissions from biodiesel-diesel blends was experienced. Considering canola biodiesel of 5 % in diesel showed considerably lower CO emissions than that of diesel fuel.

CONCLUSION

1. Biodiesel is found to be the alternative source of diesel engines.
2. Optimum techniques like hybrid RSM-Genetic algorithm, artificial neural, response surface methodology are best used in predicting optimal solutions of biodiesel based engines.

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