

ABSTRACT

Depletion of petroleum reserves and price rise of fossil fuel motivate the researchers to find alternative resources in place of conventional fuels. The use of conventional fuel in diesel engine increases the pollution in the earth atmosphere necessitates in imposing more stringent norms on emission control policies. The biodiesel obtained from various resources can strengthen the rural economy of agricultural sectors in India. Most of the studies reported that the use of biodiesel reduced exhaust emission in diesel engines due to the presence of higher oxygen molecules in it. The production and use of biodiesel in diesel engine reduces one-half of CO₂ emission in diesel engines. The reduction of CO₂ emission reduces the green gas emissions which cause the global warming in earth surfaces considerably. The combustion of biodiesel entirely removes the sulfate and sulfur oxide emissions which cause acid rain. In this work, non-edible rubber seed oil methyl ester is considered as substitute to diesel fuel. Rubber trees are planted for its latex and its seed is not used for edible purpose. The unused rubber seed oil is considered in this work for biodiesel production. This work aims to compare the different operating parameters of biodiesel blends with that diesel to improve its performance in variable compression ratio engine in agricultural sectors and in remote area power production.

The variable compression ratio is a technique in which the compression ratio is varied to raise the fuel economy and thermal efficiency of the engine. There is a reduction in fuel consumption and increase in thermal efficiency with reduction in pumping and friction losses obtained with variable compression ratio technology. The improved efficiency reduces CO₂ and other emission losses considerably. It satisfies the increasing power demand and dynamic responses in industrial and rural applications. The biodiesel obtained from rubber seed oil is produced by using a two-step transesterification processes. In this research work, the experiments are conducted with methyl esters of rubber seed oil blended with diesel at 20%, 40%, 60% and 80% on

volume basis for different compression ratios of 18:1, 19:1, 20:1, 21:1 and 22:1 at a fixed speed of 1500 rpm. The result of rubber seed oil biodiesel blends are compared with standard diesel to investigate the performance, combustion and emission characteristics of a single cylinder four stroke VCR engine at 80% load. The fuel injection pressure is varied from 140 bar, 150 bar and 160 bar with different supercharging such as 0 bar, 0.25 bar and 0.5 bar gauge pressure measured at inlet manifold at optimum compression ratio. The suitability of rubber seed oil as biodiesel, compression ratio, fuel injection pressure and supercharging pressure is recognized in this work for a variable compression ratio engine.

Exergy is the measure of work potential related to its sustainable environment. It is the process of maximum recoverable energy from fuel with respect to its operating conditions. Exergy can be lost in different ways associated with its working environment like friction, heat transfer in cylinder walls and cooling water. The reduction in irreversibility during the operation maximizes the diesel engine performance. For extensive analysis, a thermodynamic study is carried out to reveal the effect of compression ratio and supercharging on energy and exergy distributions for combination of biodiesel blends at averaged compression ratio 20. This research work motivates in using biodiesel run diesel engine for power generation in rural sectors.

The brake thermal efficiency of rubber seed oil biodiesel is improved with lower specific fuel consumption in diesel engine at optimum compression ratio. The significant reduction in CO and HC emission is obtained with these biodiesel blends in diesel engine. Better combustion pressure and heat release rate is obtained with lower blends of biodiesel. The fuel injection pressure is varied at optimum compression ratio for different biodiesel blends in a variable compression ratio engine. The increase in fuel injection pressure improves the performance with lower emissions of rubber seed oil biodiesel. The combustion pressure is increased for biodiesel blends compared to diesel. A slight drop in

heat release rate is observed for biodiesel blends due to reduction in heating value of fuel.

The combustion pressure enhancement and heat release rate with respect to crank angle variation of biodiesel blends under varying supercharging pressure is investigated. The shorter ignition delay is observed with increased combustion duration of biodiesel blends at varying supercharging conditions. The performance and combustion parameters are improved with the help of supercharging. The B20 and B40 performances are compared with diesel and are found to show improved exhaust emissions. The energy analysis is done to identify the maximum fuel energy recovered from biodiesel blends. The exergy analysis is carried out to maximize the fuel energy recovery from biodiesel blends compared to diesel.

The experimental results confirmed that the use of rubber seed oil biodiesel blends can be used in variable compression ratio engine without any modification for rural power generation. The blends of biodiesel at optimum compression ratio reduced the exhaust emissions on VCR engine. The increase in injection pressure at 160 bar and supercharging of 0.25 bar gauge pressure enhances the combustion parameters of biodiesel blends at optimum compression ratio. A slight increase in NO_x emission and exhaust gas temperatures is observed with rubber seed oil biodiesel. The NO_x emission is reduced by the usage of lower blends of biodiesel with supercharging compared to diesel fuel. On the whole, the use of biodiesel blend improves the performance of the engine without any modifications in VCR engine with supercharging at optimum compression ratio 20.

Response surface methodology is used to predict the performance and the emission analysis in a variable compression ratio engine fuelled with methyl esters of rubber seed oil blends. The separate mathematical models are developed to evaluate the engine performance and emission parameters. The input factors are compression ratio, biodiesel blends, load, fuel injection pressure

and supercharging as variables. The performance responses are brake thermal efficiency, specific fuel consumption, exhaust gas temperature, maximum pressure and ignition delay used as output parameters. The emission models are developed to predict various emissions such as carbon monoxide, hydrocarbon, nitrogen oxides and carbon dioxide as output parameters. The developed models are helpful in predicting the engine performance and emission analysis in a better way with available experimental results.

The D-optimality test is used to find the optimal solution of input parameters with its responses to maximize the engine performance and minimize the emission parameters of an engine by setting optimum target. The desirability approach finds a wider variety of optimum conditions by varying input settings to maximize or minimize the goals. The optimum results obtained with this test, have a good correlation experimental result over a broader range of applications in diesel engine.

The developed RSM model shows good agreement with the experimental data over wider range of engine performance and emission analysis for different operating settings on a variable compression ratio engine.