Abstract

In the present study, a series of experimental investigations have been conducted to explore the performance, combustion and emission characteristics with optimization of engine operation using diesel, edible (palm oil methyl ester-POME) and non-edible oil (castor oil methyl ester-COME) and their specified blends with diesel fuel in variable compression ratio (VCR), direct injection (DI) single cylinder, water cooled, multi fuel compression ignition (CI) engine. The author has focused on utilization of two methyl ester biodiesels (POME and COME) in a VCR DI compression ignition engines. The present investigations are planned after a thorough review of literature in this area. In the present investigation, many efforts have been done and introduced the possible methods of reducing the viscosity and density of biodiesel, and improvement of engine characteristics running with biodiesel. In this study, the author attempted to improve the fuel properties of biodiesels by using blending, preheating, preheating biodiesel and blending with diesel techniques. Blending is the most convenient method for the formulation biodiesel property to reduce viscosity and density as a fuel in a diesel engine, at the cost of reduction in calorific value. In this regard, the POME/COME biodiesel is blended to diesel in different volume percentages to improve certain properties. This would help in having a good understanding of the dependence of the diesel properties on the biodiesel proportion. In this analysis, the fuel properties of the blends are determined and compared to blended biodiesel standards (ASTM D7467 and BIS) and diesel fuel. Moreover, some of mixtures of the blends were tested in a diesel engine to investigate the effect of blend ratios on engine performance and emissions parameters. Then, the preheating is applied to reduce the viscosity and density of inlet fuel and is implemented in a diesel engine. In this analysis, the author attempts to use a helical coiled heat exchanger for preheating of biodiesel. While executing each test, the neat biodiesel was heated to different fuel inlet temperatures (54–138℃) in 12℃ increments before entering into combustion chamber to enhances better fuel injection and there by better fuel atomization. The aim of this study is to investigate the effects of preheating on fuel properties of biodiesel, and performance and emissions of diesel engine under full load conditions. Here also, the fuel properties of the preheated biodiesel (POME/COME) at different fuel inlet temperatures were determined and compared to biodiesel standards (ASTM 6751, EN14214 and IS15607) and diesel fuel. Keeping in view these facts, combined preheating and blending can be a viable option to enhance important fuel properties biodiesel and to increase the fraction of POME biodiesel in blends used in a CI engine. Thus, in this work, experiments were designed to study the effects of reducing POME biodiesel viscosity and density by blending along with preheating, thereby eliminating its effect on blend fuel properties, performance, combustion and emission characteristics of the engine. Experiments have been conducted to obtain performance, combustion and emission characteristics with various blend ratios of preheated POME biodiesel/diesel blends. Tests were executed at varied engine loads (0%–100%) with 20% increments. Then, similar experiments were studied under four EGR rates of 10–40% with 10% increments with an intention to reduce the high nitrogen oxides (NOx) that were prevalent at full engine loads using these blends of fuel. The results are then compared with No-EGR rate operation. This is followed by the investigation focused on the effect of preheating of intake air to improve the operating range of the engine in a different preheated biodiesel(114℃)/diesel blends mode of combustion. This investigation mainly emphases on the enhancement of combustion efficiency and the overall performance of the engine with reductions of CO and HC emissions. In this regard, an intake air preheating attachment, a shell and tube counter flow type heat exchanger was used to transfer heat from exhaust gases to intake air. The parameters were evaluated in the *engine at four elevated temperatures at 33 ℃ (ambient air), 41, 49 and 61 ℃, respectively at 90% of engine load. Along the efforts of fuel preheating and blending, and intake air preheating modifications, the author has worked mainly on engine modification of operating parameters such as compression ratios (CRs), fuel injection pressures (IPs), fuel injection timings (ITs) to enhance fuel combustion and engine thermal efficiencies. Being a fuel of different origin, the standard design parameters of a diesel engine may not be suitable for preheated biodiesel-diesel blends. Thus engine operating parameters play a key role in tuning the engine conforming to the better performance and emission standards. Therefore, the initial part of the present investigation targets at finding the performance characteristics of preheated blends of biodiesel in a VCR DI diesel engine at various combinations of CRs (15, 16, 17.5 and 18), fuel IPs (188, 200, 212 and 224 bar) and fuel ITs (19°, 23°, 27° bTDC). During this study, the engine load is fixed at 90% (10.8 kg) and EGR rate (EGR30%) for each CR-IP-IT combination tested. Finally, a thermodynamic and thermo-economic potential study for the aforementioned test results were done. In recent years, many studies have been carried out on the effect of biodiesel and its blends on thermodynamic potentials. But in those studies, no attention has been paid to the thermo-economic analysis of engines while using biodiesel blends. For this purpose, various preheated blends of POME biodiesel with diesel fuel were tested in the VCR DI compression ignition engine. The thermo-economic analysis was performed for steady-state control volume of the engine.*

From the experimentation, blending helped in pulling down the density, viscosity of the biodiesel. It is observed that 20% of neat POME mixed with 80% of diesel, whereas 10% of neat COME mixed with 90% of diesel is the best suited blend, without heating and without any modification of the engine. It meets blended biodiesel standards (ASTM D7467 and BIS). Methyl ester of POME biodiesel is the better performing fuel due to better performance and lower emissions compared to other chosen COME. As expected, the preheating of the biodiesel caused a considerable decrease in its viscosity and density with increasing temperature, thus causing them to approach the value of diesel fuel. Thus as per the result, it is suggested that POME/COME biodiesel up to 114 ℃ can be used as a substitute of diesel fuel without any significant modification at expense of increased NOx emissions. However, for fuel inlet temperature above 114 ℃, the performance was observed to be marginally inferior. Preheating biodiesel/ diesel blends caused improvement in some properties such as kinematic viscosity, density, calorific value. However, flash point decrease as the percentage of diesel increases. Thus, the blended fuel viscosity and density meets the blended fuel standards requirements ASTM D7467 and BIS for up to 60% preheated blended ratio (PPBD60). Significant improvement in engine performance with reduction in CO and HC emissions is observed with preheated biodiesel//diesel blends mixtures compared to diesel fuel. From the engine test results it has been established that up to 60% of preheated POME (114 ℃)/diesel blends (up to PPBD60) are optimum preheated mixtures and can be substituted for diesel. In addition, preheating the intake air there is a considerable decrease in CO, HC and with an increase NOx emission. It was found that combined effect of intake air preheating (61 ℃) and preheating biodiesel(114 ℃) along with blending with diesel provided better result on engine performance (BSFC and BTHE), combustion parameters (PCP and ID) and there is a considerable decrease in CO, HC and with an increase NOx emission than individual effect. Finally, the variation of engine operating parameters significantly improved engine characteristics fueled with different preheated biodiesel/diesel blends (PPBD20, PPBD40 and PPBD60) with intake air preheated at 61 ℃ under rated 90% of engine load with EGR30% rate operating conditions. The superior combinations of CR–IP–IT was found to be CR = 18, IP = 212 bar, IT = 27 ° bTDC for both preheated biodiesel/diesel blends and engine characteristics became at par with diesel fuel at this near optimal modified operating parameter. The results of economic analysis showed that all preheated biodiesel/diesel blends were more expensive than diesel fuel.