ABSTRACT

The increasing demand of energy for rapid industrialization and domestic needs are putting additional pressure on existing conventional energy sources. These are already producing more hazardous emissions into the environment than its prescribed limits. So we need some kind of energy source which must be easily available, cost-effective and most importantly it must be environmental friendly. Many researchers worked on this and found that alternative fuels have become the subjects of great interest because of lower environmental pollution, availability of feeds stock, and more consumption of fossil fuel. Amongst the various alternative sources such as biodiesel, biomass, hydrogen, and biogas, biodiesel shows similar properties as diesel fuel. It may be the best substitute for conventional energy and having an almost negligible effect on the environment and also a solution to one of the most challenging environmental issues. The vegetable oils are one of the energy sources, and also it has unique compositions (fatty acids and glycerol) which provide a good base for making biodiesel. The main issues with the use of triglycerides (vegetable oil) as a substitute for conventional diesel fuel are higher viscosity, lower oxidation stability, and lower volatility. These characteristics can be improved through mainly four methods, namely direct use and blending, micro-emulsification pyrolysis/cracking and transesterification. Among these, transesterification or alcoholysis is one of the common methods to produce biodiesel from vegetable oil with the assist of alcohol in the presence of a catalyst. Due to the low cost, physical and chemical advantages, methanol and ethanol are used as alcohol, and due to the high activity, low price, and easy availability of catalysts such as sodium hydroxide (NaOH) and potassium hydroxide (KOH) are most widely used in the transesterification reaction. In India, various type of edible (coconut, soybean, mustard, peanuts, palm, etc.) and non-

edible (neem, mahua, karanja, jojoba, jatropha, etc.) vegetable oil are available for producing the biodiesel. All the edible and non-edible plant oils have not similar fatty acid composition due to which biodiesel possess the different chemical as well as physical properties. As a biodiesel feedstock the non edible oil have gained great attention due to their high oil content, easy availability and also it can be grown in waste land which are not suitable for agriculture. Additionally, these plants do not affected by regional weather conditions and need less attention and ultimately reduced the cultivation cost.

Present thesis work includes biodiesel production from different crude vegetable oil (Castor, Linseed, Mahua and Neem) and its comparative investigation of engine performance and emission characteristic. The esterification and transesterification process is simultaneously conducted on transesterification unit for producing the biodiesel from selected vegetable oil. The experimental analysis has been conducted on Kirloskar made VCR engine fuelled with diesel and blends (B10, B20, B30, and B50) of Neem, Linseed, Mahua and Castor biodiesel at varying compression ratio (15, 16, 17 and 18). The AVL digas 444 gas analyzer has used for measure the exhaust emissions at tail pipe of the engine. The experimental result demonstrates that the brake power increased with increasing the compression ratio and reverse trends observed for BSFC. On the other hand, brake power was decreased and increased the BSFC with increasing the percentage of biodiesel in blends. Neem biodiesel was identified as higher brake power and lower BSFC than Mahua, Castor and linseed and comparable to diesel. CO exhaust emission decreased with increasing the compression ratio, and increased with increasing the percentage of biodiesel in blends. NOx formation was increased with compression ratio and decreased with increasing the proportion of biodiesel in blends. Lower NOx formation was obtained for linseed biodiesel as compared to remaining selected biodiesel and comparable to diesel. Neem biodiesel blend B20 had shown the comparable results with diesel in term of performance and emissions.

The thesis also includes the mathematical and computational model for the CI engine simulation. Modeling and simulation are widely used to study the internal combustion engine in a wide range of operation. The process of combustion in a compression ignition engine is inherently very complex due to its transient and heterogeneous character, controlled mainly by turbulent mixing of fuel and air in the fuel jets issuing from the nozzle holes. The burning duration is the specific parameter, which can be precisely estimated at starting of the computational program to predict the engine performance easily. Fuel-burning rate plays a significant role in optimizing the performance of the internal combustion engine with reduced emission. In an attempt to optimize the performance of the internal combustion engine, a novel empirical correlation is developed for fuel-burning duration in tune with the methodology proposed by an earlier investigator for the spark-ignition engine. The prepared empirical relation is a function of compression ratio, engine speed, equivalence ratio, fuel injection timing, and blending of biodiesel with conventional diesel fuel. This correlation is based on theoretical and experimental results of previous work by different authors. The correlation was integrated with the previous developed quasi-dimensional mathematical model to analyze the combustion, performance, and emission characteristics of the engine. The engine combustion, performance, and emission have been predicted with variation proportion of biodiesel in fuel, fuel injection timing, and stroke/bore ration at different engine speed and compression ratio. Predictions relating to variation of burning duration with compression ratio at different equivalence ratios are in reasonable agreement with the published data on burning duration. And also the computational results well mesh with experimental. The simulated results show that the value of brake power, indicated power, BSFC and ISFC are increased with increasing the proportion of biodiesel in the blends, and on the contrary reverse trends follows for BMEP, IMEP and peak cylinder pressure. The optimum injection timing lies in the range of 23° bTDC to 13° bTDC for brake power and indicated power both, and the lowest brake specific fuel consumption and indicated specific fuel consumption were found close to 13° bTDC. A sharp decrease in peak cylinder pressure was also observed with retarding injection timing, whereas both the retarding injection timing and increased engine speed accrue to reduced nitric oxide exhaust at exhaust valve open. From the computational results, it has found that the higher percentage improvement of all results during the initial increments in S/B ratios (0.5 to 1).

Finally, the present thesis also includes comparative energy and economic analysis of different vegetable oil plants in biodiesel production. The objective of this analysis is to select the vegetable oil plants for biodiesel production. For these purpose, considered vegetable oil plants, namely Jatropha, Mahua, Neem, Palm, Coconut, Karanja, Jojoba, and Tung. The energy analysis conducted through a life cycle assessment (LCA) approach. In this analysis, all the input and output energies during cultivation, oil extraction, and biodiesel production are considered. The energy inputs are human resources, fossil fuel, electricity, fertilizers, plants protection, and water for irrigation, expeller used for oil extraction, agricultural machinery, methanol, catalyst (H_2SO_4 and NaOH/KOH) and a transesterification unit for biodiesel production. The main product is biodiesel, co-products such as seed/oil cake and glycerine are considered as output for this analysis. Similarly, the economic analysis is conducted on the basis of input expenses and output (incomes) during cultivation, oil extraction, and biodiesel production. Based on the energy equivalents of the inputs and output, there are several economic (such as gross production value, gross return, benefit to cost ratios, productivity etc) and energy

(energy used ratio, net energy gain, specific energy, energy intensity, energy productivity etc) indices have been used extensively to measured the energy efficiency and economic value of biodiesel production from different feedstock. Neem shows the highest energy ratio (5.5164) and lowest (1.9908) for palm. The Neem shows higher value of energy productivity (0.0567 kg MJ^{-1}) i.e., unit (kg) of biodiesel production per unit (MJ) of energy consumption as compared to other remaining biodiesel plants. The net energy is positives for all the plants, but its maximum value was obtained (83.77 MJ kg^{-1}) for Neem. According to economic results, higher gross production values are obtained for Neem (222.27 Rs kg^{-1}) and Karanja (206.07 Rs kg^{-1}) as compared to other biodiesel plants. And the lower value of total production cost for Neem (78.14 Rs kg^{-1}) and palm (76.12 Rs kg^{-1}). The higher value of gross return value (168.70 Rs kg^{-1}), net returns (144.13 Rs kg^{-1}) and of benefit to cost ratios (2.84) are obtained for Neem biodiesel plants in comparison to others. The average value of productivity is higher for Neem (0.0122 kg Rs^{-1}) and Palm (0.0118 kg Rs^{-1}) than that of other remaining biodiesel plants. It means that 12.20 and 11.8 gram of biodiesel produces with expenses of one rupee respectively for Neem and Palm. According to the results of energy and economic analysis, the plantation of Neem is very economical for biodiesel production.