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EFFECT OF PREMIX AND EXHAUST GAS RECIRCULATION ON THE EMISSION CHARACTERISTICS OF BIODIESEL FUELED ENGINE

Abstract. In the present work, an attempt has been made to reduce NO_x and PM using diesel premixed compression ignition engine. Diesel fuel with 20% Jatropha oil methyl ester (JOME) blends as the main fuel injected into the cylinder and diesel as the premixed fuel injected into the intake manifold. Diesel fuel was injected into the intake manifold to form homogeneous pre-mixture and the premixture is burnt in the cylinder with the balance quantity of fuel directly injected into the cylinder. Experiments were conducted with 10%, 20%, and 30% EGR for the premixed ratio 25% and results are compared with conventional diesel fuel operation. It was observed that the diesel injection and JOME blend in the main injection results in better mixture preparation and lower emissions. Significant reduction in NO_x and PM were achieved with the mode at Rp 25% and EGR 20% in the JOME-Diesel mode of operation. The percentage increases in peak heat release rate were 40.6%, 30.6% and 22.8 % compared to CIDI mode. The premixed ratio of 0.25 with 20% EGR was observed to be optimum in D-20J comparing the performance, combustion and emission characteristics.

Keywords: diesel premix; Charge compression ignition; Jatropha methyl ester; Exhaust gas recirculation.

Introduction. The need for the energy is increasing day by day with the growth of population and requirement of modern energy consuming equipment for comfort living. The invention of internal combustion engine and developments in engine technology resulted in exploitation of the petroleum based reserves which is depleting at a rapid rate [1]. Diesel engines have been used for better thermal efficiency, however diesel engine have the disadvantage of producing smoke, smoke density and NO_x and it is difficult to simultaneously to reduces NO_x, and smoke density diesel engine [2-9]. Reducing these emissions and increasing the fuel economy of IC engines are the primary concern for all developing nations [10]. There has been a world-wide interest in the search for alternatives to petroleum derived fuels due to their depletion and concern for the environment. Biodiesel derived from edible, non-edible oils and animal fats can be used in diesel engines with little or no modifications [11-14].

Jatropha oil methyl esters are well-proven alternatives fuel to petroleum diesel [15]. Tumbal in 2016 conducted studies in a diesel engine's performance and results have been compared with those of neat diesel fuel and conclude that by advancing the injection timing from the base diesel and increasing the injector opening pressure, increase the brake thermal efficiency and reduce HC and smoke emission significantly [16]. Jatropha cultivation requires sufficient area as well as clean and good seed to generate sufficient oil [17-19]. Fast degradation and energy crisis of the environment, researchers and government must find appropriate plan to overcome these challenges and impose the biofuel policy to use the jatropha biodiesel as a replacement for diesel fuel [20]. Waste cooking oil can be used to reduce petroleum diesel consumption and lower the carbon monoxide, unburned hydrocarbon, and smoke opacity in the same time reduce the brake thermal efficiency. Waste cooking oil biodiesel blends showed similar trends when to

that of conventional diesel [21]. Even though biodiesel offers the reduction in smoke, UBHC and CO emission due to the molecular oxygen present in it, NO_x emissions are higher which can be reduced by using exhaust gas recirculation [22, 23]. Exhaust gas recirculation (EGR) is an effective way to reduce NOx emissions in diesel engine along with soybean oil methyl ester and EGR replaces the incoming air in the manifold. The experimental results reveal that soybean oil methyl ester with EGR can be used to reduce NOx and smoke intensity simultaneously [24].

Homogeneous Charge Compression Ignition (HCCI) engines have lower theses emissions due to the homogeneous fuel air mixture, in which the composition and the thermodynamic conditions are uniform throughout the reaction phase [25-28]. The low emissions of PM and NOx in HCCI engines are a result of the and fuel mixture evaporated prior to the start of the reactions. The challenges over the operation of HCCI engines are the controlling the auto-ignition of the air fuel mixture, operating range, charge preparation and cold start [29, 30]. The change in HCCI engine may be made dilute by being very lean, by stratification, by using exhaust gas recirculation (EGR), or combination of these methods. Since HCCI engine operates on lean mixtures, the peak temperatures always lower and low peak temperatures prevent the formation of NO_x [31].

Diesel Premixed Compression Ignition Engine (DPCIE). It is proposed to study the effect of diesel premixed compression ignition engine (DPCIE) mode a type of HCCI combustion mode in diesel engines [32-34]. In this method, two fuels are used. One fuel is injected into the intake air, upstream of the intake valve to obtain a premixed charge. Remaining fuel is injected into the combustion chamber through conventional injection system. The DPCIE technique reduces NOx and PM using partially premixed charge compression ignition (DPCIE) combustion [33-35]. It is observed that not much work has been done on the usage of biodiesel in DPCIE combustion mode. Hence an attempt was made to study the effect of Jatropha methyl ester biodiesel as main fuel and diesel as premixed fuel. Therefore, in DPCIE combustion takes place with a highly diluted mixture to maintain the temperature and pressure low in the cylinder and is normally restricted to low loads. In the present experimental work, the performance, emission and combustion characteristics have been studied using jatropha oil methyl esters in CIDI and HCCI modes with the following objectives:

– To find the optimum EGR percentages for the better tradeoff of soot and NO_x emissions for JOME.

– To study the effect of DPCIE combustion mode with diesel and biodiesel blends.

The conclusions arrived on various experiments conducted using DPCIE mode of combustion with diesel as premixed fuel with the premixed ratio of 0.25 and 20% JOME as main fuel with 10%, 20% and 30% EGR. The performance, emission characteristics and combustion parameters (in-cylinder pressure, ignition delay and heat release rate) are presented.

Experimental Setup. The tests are conducted on a single cylinder, four stroke, naturally aspirated, air-cooled diesel engine coupled with an electrical swinging field dynamometer. The detailed technical specifications of the engine are given in table 1. Figure 1 shows the schematic diagram of the experimental set-up.

Experimental Procedure. The engine was started with diesel and allowed to warm up till steady state conditions were achieved. Engine Speed, fuel consumption rate, exhaust emissions (HC, CO, and NO_x), smoke intensity, pressure-crank angle diagram and exhaust gas temperature were measured at various loads. The experiment was repeated at various loads with 20% JOME blends with diesel. The experiments were conducted on a CIDI engine maintained at 25%, 50%, 75% and 100% of brake power output at the speed of 1500 rpm with modified inlet manifold to operate the engine in DPCIE combustion mode. The experiment was repeated with premixed ratios of 0.25 at various power outputs. The notations are used in DPCIE mode:

D-20J mode - Diesel (manifold injection)-20% JOME and 80% Diesel blends (main injection).

Rp - The ratio of the energy of premixed fuel Qp to the total energy Q_t.

$$Rp = Q_p/Q_t = (m_p*CV_p)/m_p*CV_p + m_d*CV_d \,. \quad (1)$$

Where m is the mass of fuel and CV is the lower calorific value and subscripts p and d refer to premixed and directly injected fuel, respectively.