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ENGINE PERFORMANCE AND EMISSIONS OF DI DIESEL ENGINE OPERATING ON BIODISEL (TESSI OIL) WITH EXHAUST GAS RECIRCULATION (EGR)

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Abstract *— One of the most important elements to effect world economy and politics was sustainability of petroleum resources. Being the main source of world energy supply, the world is presently facing with the crisis of fossil fuel depletion and environmental degradation. Moreover, the increasing demand of petroleum in developing countries like China, Russia and India has increased oil prices. The present work is to investigate the use of biodiesel obtained from Teesi Seed Oil (B20) with different flow rate of Exhaust Gas Recirculation (EGR) (5%, 10%, 15%, and 20%). A single cylinder, water-cooled, constant speed direct injection diesel engine is used for experiments. The performance and emission characteristics are analyzed at constant speed with varying load condition. The results obtained shows reduced NOx emission for all EGR ratios in both diesel and biodiesel (B20).*

Keywords- *Biodiesel, Emission, EGR, Teesi seed*

I. INTRODUCTION

Biodiesel (methyl or ethyl ester of fatty acid) was obtained from various naural resources like virgin or used vegetable oils (both edible and non-edible) and animal fat. Among them, the main sources for biodiesel production can be non-edible oils obtained from plant species such as Jatrophacurcas (Ratanjyot), Pongamiapinnata (Karanj), Calophylluminophyllum (Nagchampa), Hevcabrasiliensis (Rubber) etc. The combustion of biodiesel in compression ignition (CI) engines in general results in lower smoke, particulate matter, carbon monoxide and hydrocarbon emissions but higher NOx compared to standard diesel fuel combustion [1–3]. To reduce NOx, the EGR technique was used. In exhaust gas recirculation two methods were available. One was replacement EGR and other one was additional EGR [2]. In the first method, some of the air entering the engine was replaced by exhaust gases. This means that the air/fuel ratio and the exhaust flow leaving the engine were both reduced. In the second method, exhaust gases were added to the air mass flow entering the engine. By this procedure the air/fuel ratio and the exhaust mass flow were kept constant [3]. Also, the application of EGR will reduce the NOx formation by three effects, namely dilution effect, thermal effect and chemical effect [4]. Out of these dilution plays a major role in NOx reduction for diesel-fueled operation [5]. In this study, the combined effects of Teesi oil biodiesel combustion with the incorporation of exhaust gas recirculation (EGR) on the engine performance and emissions characteristics were analysed and compared with the results obtained from the engine operating on diesel.

Teesi with the binomial name: Linum usitatissimum, was a member of the genus Linum in the family Linaceae. It was a food and fibre crop that was grown in cooler regions of the world. Linum usitatissimum was native to the region extending from the eastern Mediterranean, through Western Asia and the Middle East, to India. The physical properties of flaxseeds have been evaluated as a function of seed moisture content, varying from 6.09% to 16.81% (d.b.). In the moisture range, seed length, width, thickness, arithmetic mean diameter, and geometric mean diameter increased linearly from 4.27 to 4.64 mm, 2.22 to 2.38 mm, 0.85 to 0.88 mm, 2.45 to 2.63 mm and 2.00 to 2.12 mm respectively with increase in moisture content. One thousand seed weight increased linearly from 4.79 to 5.32 gr. The true density increased with moisture content from 1000 to 1111 kg/m3 while bulk density decreased 726.6 to 555.6 kg/m3in the range of moisture content between 6.09% and 16.81%, d.b.

II. EXPERIMENTAL SETUP

A single cylinder water cooled, four stroke direct injection compression ignition engine with a compression ratio of 17.5:1, developing 5.2 kW at 1500 rpm (Kirloskar TV-1) is used for this study. The overall view of the experimental setup is shown in figure 1. The engine was run at a constant speed of 1500 rpm at different loads, the loads were applied to the engine through an eddy current dynamometer. The engine was run at various loads of the eddy current dynamometer (20%, 40%, 60%, 80% and 100%). The dynamometer was interfaced to a control panel. The emissions like HC, CO, NOx were measured in the AVL Di gas analyzer and smoke density was measured by smoke meter. The exhaust gas temperature was measured using K-type thermo couple. After all the readings were taken, the leftover diesel was drained out of the tank and biodiesel at various ratios (B20, B40, B60, B80 and B100) was poured. Same steps were followed and the readings were noted down for the biodiesel. The EGR system consists of a piping system taken from the engine exhaust pipe. The amount of exhaust gas recycling into the inlet manifold was controlled by means of valves. The recirculated exhaust gas flows through orifice with manometer for measuring the flow rate, before mixing with the fresh air. The engine was run by using diesel and B20 biodiesel (Teesi oil) with 5% EGR, 10% EGR, 15% EGR and 20% EGR at various load condition (20%, 40%, 60%, 80% and 100%).

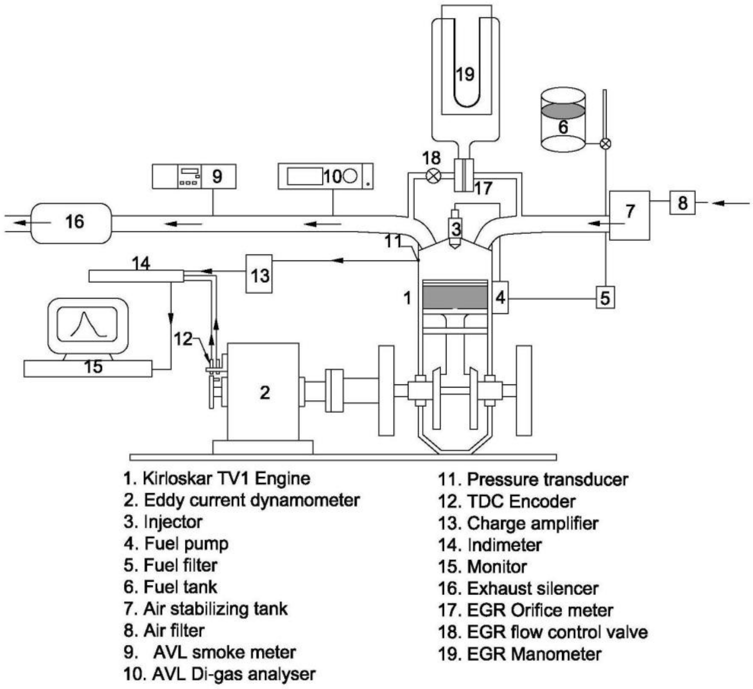

Fig 1 Experimental setup

Table 1 Properties of fuel

	Diesel	B20
Viscosity @ 40°C cSt	2.57	3.32
Flash Point (°C)	37	54
Fire Point (°C)	40	68
Net Calorific value (kJ/kg)	34178.6	40081
Specific gravity @15°C	0.8291	0.8518
Cetane Number	48	55

III. RESULTS AND DISCUSSION

3.1 Specific Fuel Consumption

For diesel and bio diesel, the variation of specific fuel consumption with brake power was shown in Fig 2. For increasing the level of EGR the specific fuel consumption decreased for both diesel and biodiesel. The lower value was shown in diesel without EGR while compare with biodiesel blend with EGR and without EGR. This was due to lower calorific values and higher viscosity, and density and boiling point [6].

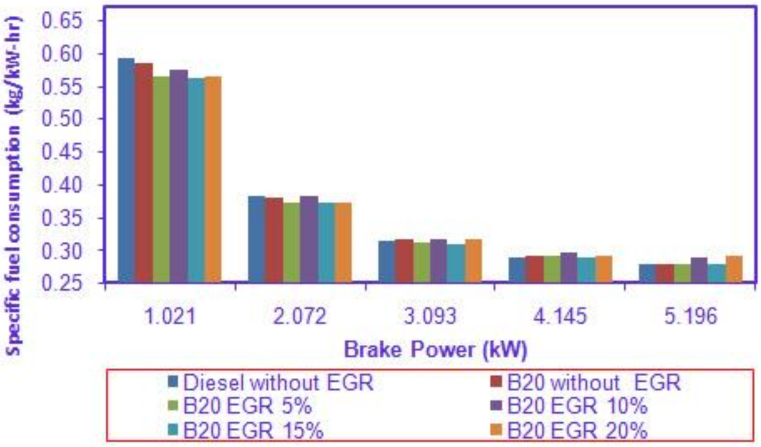

Fig 2 Specific fuel consumption Vs Brake Power

3.2 Brake Thermal Efficiency

Figure 3 indicate the variation in brake thermal efficiency with brake power. Brake thermal efficiency with and without EGR was found to be comparable for diesel and bio diesel (B20). At full load the brake thermal efficiency decreases with increase in EGR flow rate. The reduction in efficiency was due to the high EGR flow rates that results in deficiency in oxygen concentration in combustion process at full load and larger replacement of air by EGR [7]. The higher specific heat capacity of both CO_2 and H_2O and high flow rate of EGR reduces the average combustion temperature in the combustion chamber resulting in the brake thermal efficiency to reduce at full load.

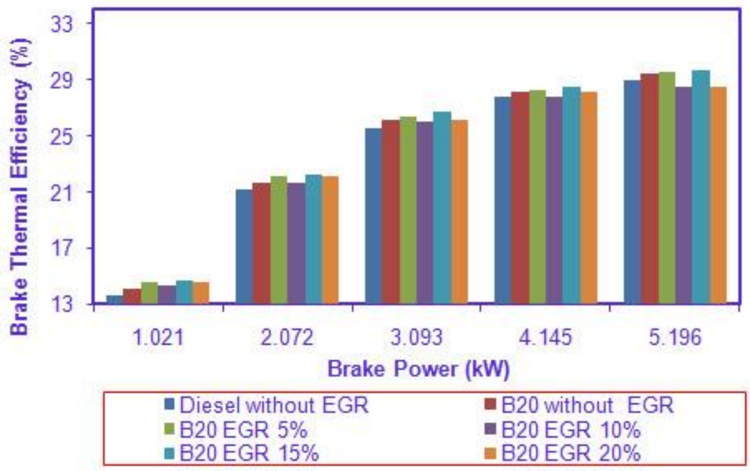

Fig 3 Brake thermal efficiency Vs Brake Power

3.3 Exhaust Gas Temperature

The variation of exhaust gas temperature with brake power was shown in Fig. 4. It was observed that with increase in load, exhaust gas temperature also increases. The exhaust gas temperature decreases marginally with increase in EGR flow rates. In general due to the EGR there was a reduction in peak combustion temperature hence the exhaust gas temperature drops down which was also due to the replacement of combustible mixture by inert gases.

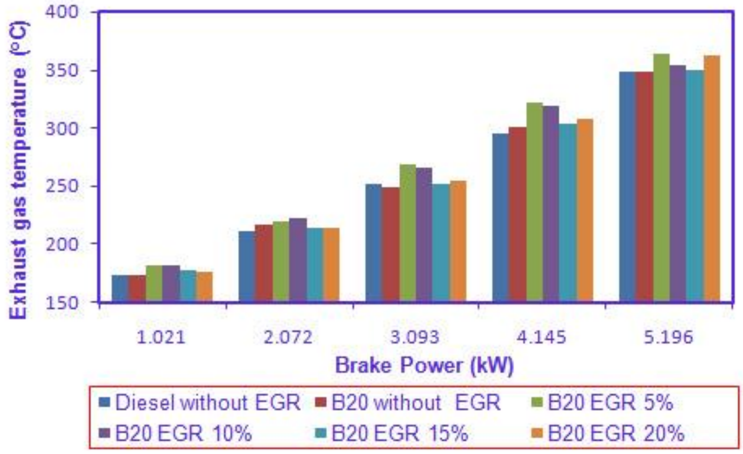

Fig 4 Exhaust gas Temperature Vs Brake Power

3.4 Smoke Density

Variation of smoke density with brake power was shown in fig 5. Higher smoke density of the exhaust was observed when the engine was operated with EGR compared to without EGR on diesel. EGR reduces availability of oxygen for combustion of fuel, which results in incomplete combustion and increased formation of PM. The increase in smoke concentration was due to partial replacement of air by exhaust gases, which results in combustion instability [14]. The optimum EGR percentage was found to be 20% for varied load conditions, which gives lesser, smoke compared to diesel and also the NOx reduction was higher.

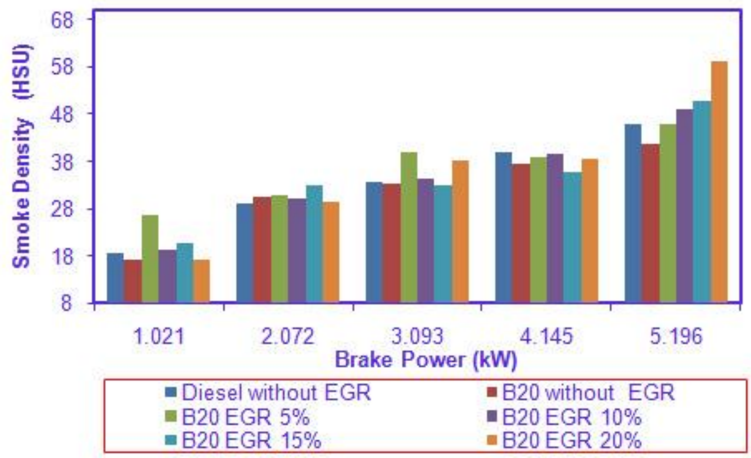

Fig 5 Smoke Density Vs Brake Power

3.5 Oxides of Nitrogen

Figures 6 indicate the variation of nitrogen oxide with brake power. Generally the NOx emission tends to reduce drastically with increase in EGR percentage for all load conditions due to the rise in total heat capacity of the working gases by EGR, which lowers the elevated peak temperature [5, 13]. The NOx emission reduces with increase in EGR flow percentage this was due to the presence of inert gas (CO_2 and H_2O) in the combustion chamber, which reduces the peak combustion temperature, and also it replaces the oxygen in the combustion chamber. As a result of reduction in both parameters the NOx reduces drastically with EGR.

3.6 Carbon Monoxide

Fig.7 depicts the variation in CO levels for diesel and biodiesel operation with various EGR levels for different load conditions. The CO emission at no load and full load was higher. With increase in EGR percentage at no load it does not have dramatic effect on CO variation. The increase in CO concentration was due to the partial replacement of oxygen in inlet air by inert gas, which results in deficiency in oxygen concentration, thus increasing the concentration [8].

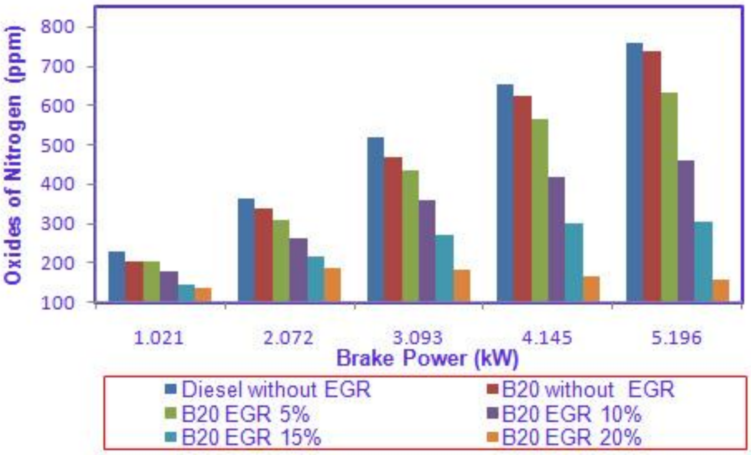

Fig 6 Oxide of Nitrogen Vs Brake Power

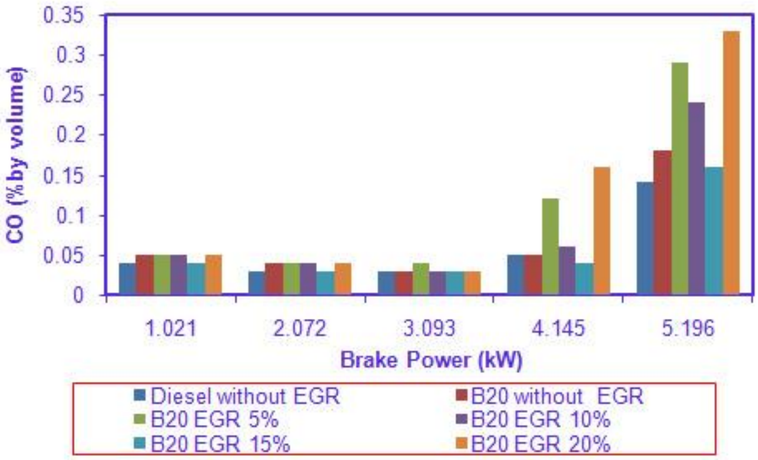

Fig 7 Carbon monoxide Vs Brake Power

3.7 Hydro Carbon

Fig. 8 depicts the variation of hydrocarbon with brake power. The HC variation follows a close trend with increase in EGR resulting in increase in HC emission. Reduction in oxygen in the inlet charge by the EGR admitted into the cylinder makes the HC emission to increase. This was due to oxygen content in biodiesel compensating for oxygen deficiency and facilitating complete combustion.

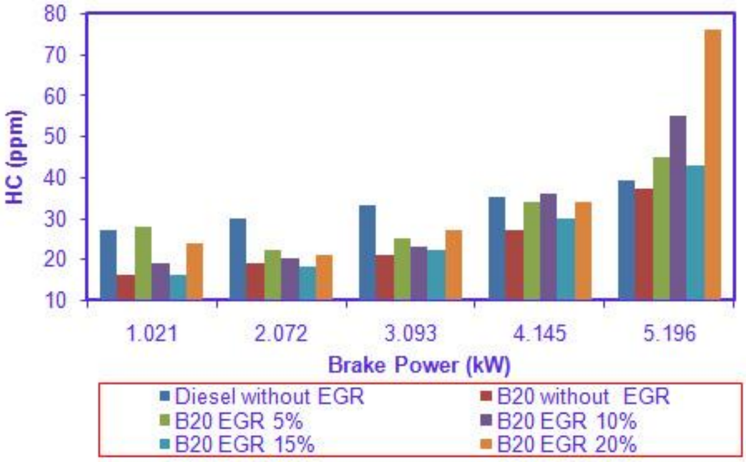

Fig 8 Hydrocarbon Vs Brake Power

IV. Conclusion

The present study was carried out on single cylinder DI diesel engine with a design modification to run on exhaust gas recirculation (EGR) system. The main objective of the present investigation was to evaluate suitability of EGR system for reduction of oxides of nitrogen (NOx) of biodiesel fueled diesel engine and also to evaluate the performance and emission characteristics of the engine with different EGR rates. The experimental results show that with application of EGR, overall engine performance and emission characteristics with biodiesel and its blends were slightly better than the diesel fuel. Increase in fuel economy with the reduction in NOx emissions was obtained at EGR rate of 15%. The results obtained both with and without application of EGR, prove that the Carbon monoxide, hydrocarbon and smoke density from the biodiesel (B20) was found higher than diesel fuel during the whole experimental range. From the experimental study it can be suggested that, at low loads more than 15% EGR rates can be employed but at higher loads maximum EGR rate was limited to 15% to obtain better results from exhaust gas recirculation system.

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