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ARTICLE

COMBUSITON AND EMISSION ANALYSIS OF OXYGENATED MUSTARD OIL BIODIESEL WITH EXHAUST GAS RECIRCULATION IN COMPRESSION IGNITION ENGINE

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ABSTRACT

Diesel Engines are more suitable for using Biodiesel fuel extracted from oil plants. In this research, biodiesel was separated from the mustard oil and it was blended with the diesel in the ratio of 5%, 10%, 15%, and 20%. All the blends were added with 10% of Di-tetra-butyl-peroxide and it was tested in a diesel engine to study its performance and emission characteristics. The 20% of mustard oil mix was included with the 15% of Exhaust Gas Recirculation to lessen NOX discharges and its exhibition and emanation characters were contrasted and that of others. From the results, the CO emissions reduced by 9.5% and HC by 2.4% the NOX emissions were decreased by 4.7% for the 20% blend of mustard oil with 15% EGR when compared to diesel fuel.

KEY WORDS
Biodiesel, Brake thermal efficiency, Mustard oil, DTBP additive, NOX emission reduction

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INTRODUCTION

Infection The automobile sector is the major consumer of petroleum-based products and it is responsible for the release of various harmful emissions into the environment like HC, CO, NOX, soot and greenhouse gases like CO_2 [1]. To control the release of these harmful exhaust gases into the environment various countries have initiated and implemented different pollution standards to the Automobile manufacturers according to the vehicle type in order to keep the air quality clean. As the crude oil reserves in our country are less than 0.5% of world total reserves, it is important to locate an elective wellspring of fuel for powering internal combustion engines [2]. It is likewise seen that the raw petroleum-based engines release harmful emissions and this will pollute the environment. It is necessary to move towards an alternative source of fuel to reduce our dependence upon the petroleum-based products and also to satisfy the rigorous emission norms. In recent times, EURO VI emission norms are recommended for the automobiles. As there is no major modification required for using alternative fuel, diesel engines are preferred to use the alternative fuel. Oil extracted from vegetable oils is becoming trending in the field of alternative fuels to investigate its performance and emission characters [3]. The oil extracted from the vegetable seeds has more triglycerides and this is suitable for blending it with diesel fuel. The glycerol content in the vegetable oil can be evacuated by the trans-esterification process, before mixing it with the diesel. As a result of the more oxygen content in the biodiesel, the creation of hydrocarbon (HC) and carbon monoxide (CO) is extremely less [4]. Based on the environment and the availability of the oilseeds, the biodiesel used can be selected. The yield of mustard oil is 227 to 531 liters per acre, so it was selected for the production of biodiesel through the trans-esterification process [5]. Researches in Di-tetra-butyl-peroxide (DTBP) additive effect on biodiesel proved that it can reduce the HC, CO & NOX emissions simultaneously on biodiesel [6]. Many types of research in the EGR have proved that it can reduce the NOX emission formation for diesel as well as biodiesel in the CI engine [7-9]. In this research, we have examined the combined effect of the DTBP additive as well as the EGR produced by the Mustard oil biodiesel blends on the performance and emission characters. In this research, the mustard oil-based biodiesel was added with Di-tetra-butyl-peroxide (DTBP) and mixed with diesel in different proportions and it was tried in a diesel motor with and without Exhaust Gas Recirculation (EGR).

PREPERATION OF BIODIESEL

The oil separated from the mustard seed experienced a trans-esterification procedure to lessen the fuel viscosity by expelling the free unsaturated fat substance. In this process, initially, the raw oil was mixed with the methanol (ratio of oil to methanol is 5:1) in the presence of a small amount of sodium hydroxide (16-18 grams per lire of raw oil) [10 - 15]. At that point, it was ceaselessly mixed and warmed and kept up at a temperature of 65°C for about an hour and afterward moved into a separation funnel to settle down. After 5-7 hours, the fatty acid (in the form of glycerol) present in the oil was settled at the base of the pipe and the biodiesel on the top. The glycerol was separated and removed, the remaining biodiesel was washed with deionized water for removing extra soap content and the final product is heated again to remove the traces of water particles [16 - 18]. The different properties of diesel and mustard oil were estimated by the ASTM measures and given in [Table 1]. The kinematic viscosity, flash point, fire point cloud point, pour point, the density of the mustard oil biodiesel is more noteworthy than that of the unadulterated diesel fuel which influences the fuel evaporation qualities. The calorific estimation of the mustard oil biodiesel is lesser than that of the diesel which can prompt increment in the fuel utilization. These properties of the fuel impact greatly on the performance as well as the emission characters of the engine.

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Table 1: Comparison of properties of mustard oil biodiesel and diesel

S.No	Properties	Mustard oil	Diesel
1	Kinematic Viscosity (mm^2/s)	6.6	4.2
2	Flash point (˚C)	158	57
3	Fire point (˚C)	187	74
4	Cloud point (˚C)	4	-12
5	Pour point (˚C)	-12	-23
6	Specific gravity	0.895	0.841
7	Cetane Number	38	50
8	Calorific value (kJ/kg)	39857	44950

The readied Mustard oil biodiesel was mixed with diesel in the proportion of 5:95, 10:90, 15:85, and 20:80 by volume and assigned as MB5, MB10, MB15 and MB20 separately. Since the cetane number of mustard oil is low, it is difficult to self-ignite the fuel. Hence, 10% of Di-tetra-butyl-peroxide (DTBP) was added to all the blends as cetane improvers to accelerate the ignition process. This also acts as an oxygenated additive to reduce HC, CO simultaneously. Studies have also been made by using octanol and heptanol additives with mustard oil blends and the results are found to be impressive [19-20]. Because of the high thermal stability of DTBP and commercial availability, it was selected as an additive. DTBP enhances the rate of chain initiation for HC oxidation by giving up free radicals through decomposition during the ignition delay period.

METHODS

Biodiesel mixes were tried in a solitary chamber, 4-stroke, diesel engine. The particular of the motor was given in [Table 2]. The heap on the motor was controlled and changed by shifting the heap on the swirl current dynamometer with the assistance of a burden cell unit. The motor speed set at 1500 rpm. The presentation and outflow characteristics were estimated at various brake powers (1.6 kW, 3.2 kW, 4.8 kW, 6.4 kW, and 8 kW) of the motor. The in-chamber pressure was estimated for 100 motorcycles utilizing a weight transducer mounted on the chamber head and recorded in the PC utilizing "AVL Indicom programming". The recorded weight information esteems were arrived at the midpoint of to figure the Heat discharge rate (HRR). Exhaust emanations like Hydrocarbon (HC), Carbon monoxide (CO), and nitrogen oxides (NOX) were estimated from "AVL Digas analyzer". The smoke thickness was estimated utilizing "AVL smoke meter". The time taken for utilization of 10cc of fuel from the burette was noted utilizing stopwatch at all test conditions. The engine experimental layout was shown in [Fig. 1].

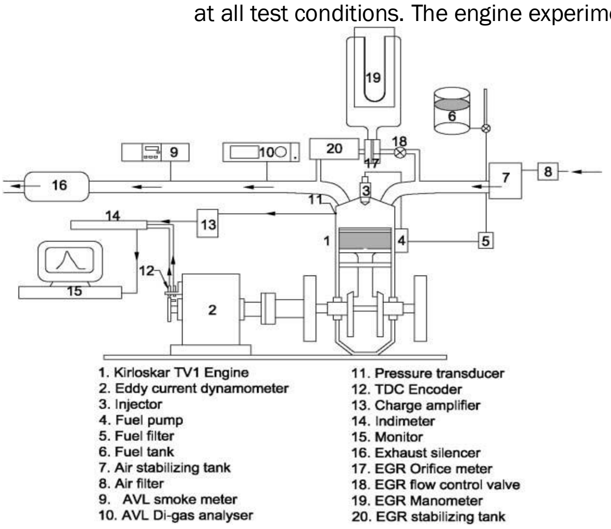

Fig. 1: Engine experimental layout

Table 2: Engine specification

Make	Kirlosar-TV 1
General details	Four stroke, compression ignition, water cooled, direct injection
Bore	87.5 mm
Stroke	110 mm
Compression ratio	17.5:1
Rated speed	1500 rpm
Injection pressure	220 bar
Fuel injection timing	23 BTDC
Rated output	8 kW
Speed	1500 rpm

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Initially, the engine was warmed up by running it with diesel fuel for 15 minutes to achieve a stable operating condition. The speed of the engine was maintained constant at 1500rpm at all loads by adjusting the fuel flow rate manually. Then the engine was operated with all the prepared test fuels with a break of 30 minutes between each fuel to cool the engine. A 15% EGR was used with the MB20 blend. The percentage of EGR was controlled by adjusting the flow valve manually with the help of orifice and manometer reading. The exhaust gas analyzer probe was inserted in the exhaust tailpipe. After each measurement, the probe was taken out and exhaust gases were purged from the probe. The exhaust emission was measured three times for each test condition and averaged. The averaged value was considered for the analysis.

RESULTS AND DISCUSSION

The aftereffects of Brake Thermal Efficiency (BTE) of the diesel motor powered by MB biodiesel – diesel mixes appeared in the [Fig. 2]. From [Fig. 2], it was deduced that the BTE of all the test fuels is by all accounts expanded up to 80% (6.4kW) load and indicated a slight drop at 100% (8 kW) load. The BTE was diminished with increment in MB biodiesel mix rate [21]. At full burden, the test fills MB5 and MB20 indicated a 3.5% and 8.5% decrease in BTE separately when contrasted with slick diesel. This is on the grounds that the vitality thickness of mustard oil biodiesel was not as much as diesel. A similar impact likewise expanded the particular fuel utilization for MB biodiesel mixes [21]. The EGR further decreased the BTE of MB20 by 2.7% compared to without EGR. This is due to the deterioration of in-cylinder combustion caused by the dilution of intake air by exhaust gases. The EGR reduced oxygen concentrations in the intake and also cause a drop in combustion temperature which in turn affects the combustion efficiency.

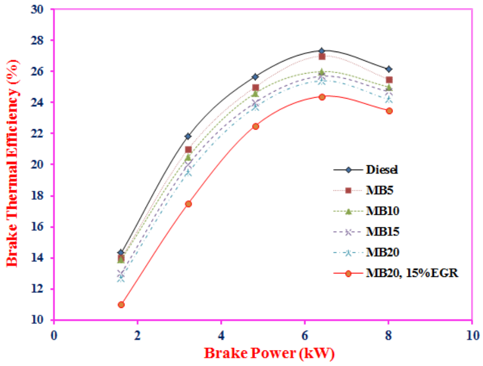

Fig. 2: BTE (%) vs. Brake Power (kW)

The [Fig. 3] shows that the smoke emanation is decreased with increment in the biodiesel mix. Typically the smoke discharge will increment with increment in the biodiesel mix as more measure of fuel is gathered in the burning chamber because of lower Cetane number of biodiesel [24-26]. The unadulterated diesel fuel shows the most extreme smoke discharge while MB20 shows the least smoke outflow among the test powers. At full burden condition, the MB20 shows a smoke decrease of 44.5% than that of diesel, this is a direct result of the impact of innate oxygen present in the mustard oil biodiesel ester and furthermore in the additional DTBP added substance which advanced more oxidation of sediment molecule. The MB20 with EGR shows higher smoke than without EGR but still exhibits a smoke reduction of 11.4% when compared to diesel. The reason for the increase in smoke with EGR for MB20 is due to a reduction in combustion temperature which favors condensation of Poly Aromatic Hydrocarbon (PAH) and polymerization of lower-order molecules to form a large unsaturated molecule. These two destined to form soot and thereby increasing the smoke.

[Fig. 4] demonstrates that the CO emanation for the MB20 is seen to be least among the test energizes because of the accessibility of oxygen in its sub-atomic structure which elevated CO oxidation to CO2. As the Brake mean effective pressure expands, the arrangement of the CO discharges will increment [27]. Indeed, even the brake mean effective pressure is more in the MB fuel contrasted with that of the diesel; the development of the CO emanation is not as much as that of the diesel [28]. The discharge arrangement of the CO outflow is diminished with the expansion in the mix, the most extreme decrease of 28.5% than diesel was seen when MB20 was tried at 8 kW brake power. This is because of the nearness of oxygen atom in the mustard oil biodiesel and DTBP added substance which advances CO oxidation. The MB20 with 15% EGR shows the CO formation of 6.38% lesser than that of the diesel.

From the [Fig. 5], it is seen that the NOX discharges expanded with increment in the biodiesel mix rate in light of the advancement of high brake mean effective pressure in the ignition chamber that can bring about high burning temperature and furthermore because of the essence of oxygen in the sub-atomic structure of MB and DTBP that upgraded the fuel oxidation and improved the ignition [30]. It is obviously observed from [Fig. 5] that the arrangement of NOX emanation is more in MBD20 without EGR, on account of the higher in-chamber pressure created from the MB fuel [29] which is brought about by high pinnacle heat discharge rate. High ignition temperature and oxygen are the hotspots for the development of NOX. Thus, the NOX discharge is expanded with increment in the mix rate. The NOX emission is increased by 1.5%, 4.7%, 7.9%, and 11.1% for the MB5, MB10, MB15, and MB20 respectively, but a reduction of 4.7% is observed with

15% EGR when compared to that of diesel. The MB20 with 15% EGR has shown lesser because of the dilution effect which reduced both combustion temperature and oxygen concentration.

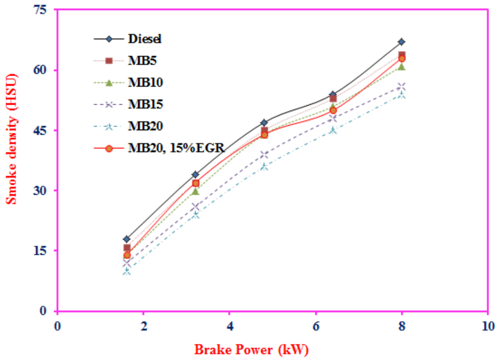

Fig. 3: Smoke (HSU) vs. Brake Power (kW)

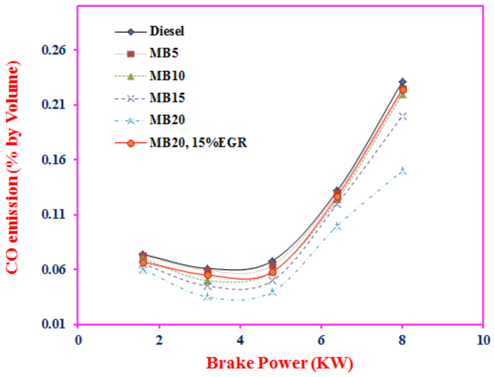

Fig. 4: Brake Power vs. CO emission

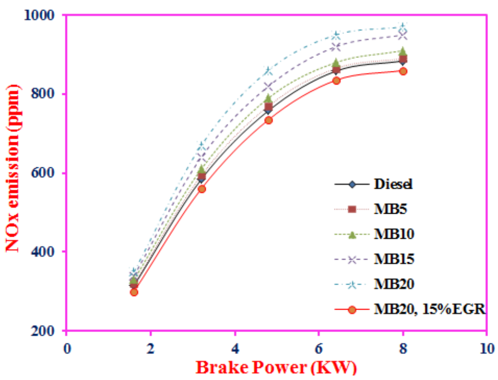

Fig. 5: Brake Power vs. NOX emission.

[Fig. 6] shows the HC outflow, all things considered, HC emanations are created in the motor because of the blend of air-fuel blend fixation, poor dissipation and blending attributes of fuel and temperature [31]. The HC discharge is diminished by about 4.7%, 7.1%, 11.9%, and 16.6% than that of diesel for MB5, MB10, MB15, and MB20 individually. Indeed, even with the expansion of 15% EGR, MB20 indicated a decrease of 2.4% HC emanation than that of diesel. Since biodiesel mixes improved the oxidation of hydrocarbon through the inborn oxygen particle in it. Diesel fuel has demonstrated the greatest HC outflow among the test energizes. This might be expected to in-complete ignition. The DTPB added substance likewise impacted HC discharges by improving hydrocarbon oxidation by expanding the oxygen focus in the biodiesel mixes. The EGR restrict the complete combustion by reducing the temperature which affects the evaporation of fuel droplets inside the combustion chamber and oxygen content in the intake air.

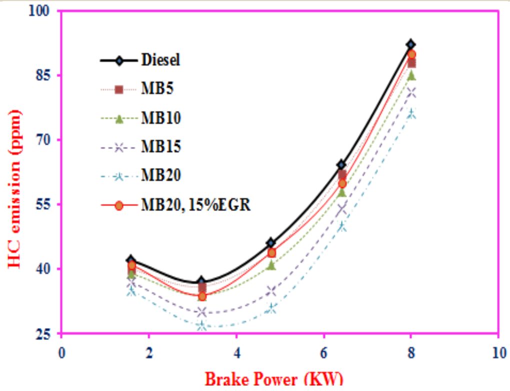

Fig. 6: HC emission vs. Brake Power

[Fig. 7] demonstrates that the greatest chamber pressure was accomplished for the MB20 fuel, this is a direct result of consuming of higher thickness bead of biodiesel mixes that is brought about by high thickness and consistency nature of biodiesel. This impact likewise expanded the specific fuel consumption of the mustard oil biodiesel [32]. So the chamber pressure is expanded with increment in the MB biodiesel mix. The most extreme pressure of MB 20 fuel was 8.4% more than that of the diesel and furthermore the most elevated pinnacle pressure created among the mixes. The maximum pressure observed for MB20 with 15% EGR was found to 1.9% lesser than that of the diesel. It is due to the presence of exhaust gas in the mixture which reduced the cylinder pressure by decreasing the heat release rate.

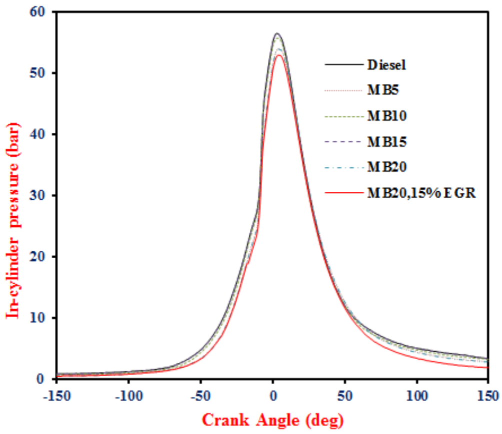

Fig. 7: Cylinder Pressure w.r.t Crank Angle

[Fig. 8] shows the Heat discharge pace of Diesel was higher than the biodiesel mix. This is a result of the higher calorific estimation of diesel contrasted with that of the MB mix. The reduction of about 8.8% and 18.45% of HRR was observed for the MB20 blend and MB20 with 15%EGR. Also the MB20 with 15% EGR have the lesser heat release rate of all the blends as it have the lesser calorific value [33, 34]. Thus the calorific value of the fuel plays a major role in the heat releasing rate.

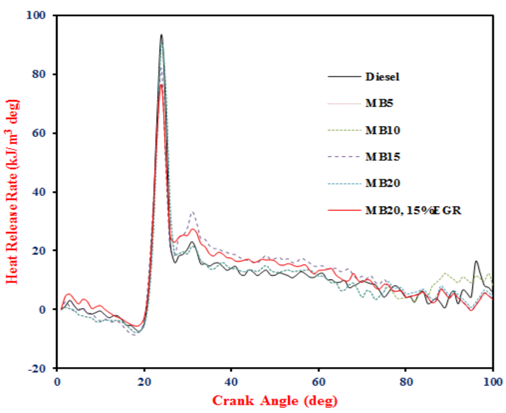

Fig. 8: Heat release rate w.r.t crank angle

CONCLUSION

Subsequently, the mustard biodiesel was arranged and mixed with the diesel in different proportions, it was then tried in a solitary chamber diesel motor. Its performance and effectiveness characters were found. Specific fuel consumption was expanded for all mixes of MB with increment in mixing proportion with DTBP added substance. Brake warm productivity was diminished with increment in the mixing proportion of the fuel with DTBP added substance. HC and CO emissions were diminished with increment in the mixing proportion of the mustard oil biodiesel with DTBP added substance. NOX emission was expanded with increment in the mixing proportion. The impact of the expansion of EGR demonstrates the significant increment and diminishing in specific fuel consumption and brake thermal efficiency individually. The results show that the utilization of mustard oil biodiesel with DTBP added substance will lessen HC and CO however increment NOX emanations. The joined utilization of MB20 with 15% EGR shows decreasing all the discharges from a vehicle. Thus the impact of the DTBP added substance was useful for the decrease of HC and CO discharge however it will build the NOX emanations. Along these lines, the EGR was utilized to lessen all the discharges of the engine.

CONFLICT OF INTEREST

There is no conflict of interest.

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None.

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