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Performance Combustion and Emission Characteristics on DI Diesel Engine using Bio Additive

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ABSTRACT

One of the major problems in the contemporary world is pollution. The major contribution in this area comes from automobile emissions and industries. Diesel being one of the major fuels is also a major contributor in adding harmful pollutants into the atmosphere. In order to meet the stringent emission norms, the polluting components in the fuels need considerable reduction. Fuel characteristics play a major role in engine efficiency and engine emissions directly or indirectly. In this present work experiment was conducted on Kirloskar TV-1 engine (single cylinder, four stroke, constant speed, and water cooled diesel engine). The experiments were conducted by kriya bio additive in different ratios with diesel. The quantity of bio additives were increased gradually in the order of 1ml, 1.5ml, 2ml, 2.5, and 3ml respectively. Emission parameters such as HC, smoke density, NOx, and CO_2, characteristic were determined for diesel and also for bio additive blends. Bio additives mixed with diesel in different ratios by volume based, it is noticed that the bio additive added diesel enhances the cetane number and reduced the emission.

Keywords: *Bio additive, Combustion, Emission.*

1. INTRODUCTION

Alternative fuels for diesel engines are becoming increasingly important due to diminishing petroleum reserves and the environmental consequences of exhaust gases from petroleum fuelled engines. A number of studies have shown that triglycerides hold promise as alternative diesel engine fuels. So, many countries are interested in that. The depletion of conventional fossil fuels, growing of air pollution caused by combustion of fossil fuels, and their increasing costs make alternative fuel sources more attractive. Petroleum-based fuels are limited reserves concentrated in certain regions of the world and are shortening day by day [1–2].

Energy is an essential and vital input for economic activity. Building a strong base of energy resources is a pre-requisite for the sustainable economic and social development of a country. Indiscriminate extraction and increased consumption of fossil fuels have led to the reduction in underground-based carbon resources. Bio fuels will mitigate the vulnerability and the adverse effects of use of fossil fuels. Several developed countries have introduced policies encouraging the use of bio fuels made from grains, vegetable oil or biomass to replace part of their fossil fuel use in transport in order to achieve the following goals; to prevent environmental degradation by using cleaner fuel, to reduce dependence on imported, finite fossil supplies by partially replacing them with renewable, domestic sources and to provide new demand for crops to support producer income and rural economics [3-4].

Yao ChunDe et.al studied the matter extracted from palm oil was considered as gasoline additive. The effect of various percentages (0.2%, 0.4% and 0.6%) of the bio-additives on fuel economy of SI engine respectively running on prime gasoline, gasoline with known components, ethanol gasoline, and methanol gasoline under typical urban operation condition 2000 r/min was investigated. The results showed that the bio-additives can remarkably improve the fuel economy of SI engine while operating on all kinds of fuel. The optimal ratio of bio-additive to gasoline depends on the fuel used and on the different engine operating conditions. Besides, the experiments of constant volume combustion bomb, analysis of in cylinder processes, the synchrotron radiation and high-temperature friction were conducted to probe into the mechanism of the bio-additive impact on fuel economy. It indicated that the bio-additives can increase the maximum cylinder combustion pressure, improve exhaust emissions and largely reduce the frication coefficient [5].

Asep Kadarohman et.al studied, Research on the potency of essential oils as diesel fuel bio-additives has been reported. It also has been found out that clove oil has a better performance than turpentine oil on decreasing Break Specific Fuel Consumption (BSFC) and reduces the exhaust emissions of the engine. Clove oil is essential oil the content of which is made of eugenol acting as the main component. Eugenol has a bulky structure, two oxygen atoms and can form eugenyl acetate from ester reaction. Eugenyl acetate has a bulkier structure and higher oxygen content than eugenol which leads to optimizing the process of fuel combustion. This experiment can give information about the potency of the bio-additive based on clove oil and eugenol and about the influence of oxygen enrichment with eugenol on the performance of the diesel fuel bio-additive. In general, this experiment covered three stages. The first step is the characterization of the diesel fuel bio-additive using a GCMS and FTIR spectrophotometer. The second step is the characterization of the diesel fuel bio-additive and composition optimization. The final step is conducting a diesel fuel bio-additive performance test on one cylinder engine on a laboratory scale. The results of the carried out experiment show that clove oil, eugenol and eugenyl acetate can decrease Break Specifi c Fuel Consumption (BSFC) and reduce the exhaust emissions of the engine as well as oxygen enrichment can help in reaching optimal fuel combustion [6].

Gong Yanfeng et.al investigated, 2-methoxyethyl acetate (MEA) can be used to decrease exhaust smoke as a new oxygenated additive of diesel. Several fuel blends which containing 10%, 15% and 20% MEA were prepared. The effects of MEA on engine's power, fuel economy, emissions and combustion characteristics were studied on a single cylinder DI diesel engine. Under the same speed and load conditions, the maximum cylinder pressure decreases when fueled with the blends, while the ignition delays and the combustion duration becomes shorter. The engine emissions of smoke, HC and CO are reduced when MEA is added in diesel. However, MEA has a little effect on NOx emissions. When fueled with MEA15, the coefficient of light absorption of smoke opacimeter decreases about 50% with expense of 5% power, and the engine's thermal efficiency increases about 2% [7].

Frank Lujaji et.al studied The aim of this study is to evaluate the effects of blends containing croton mogalocarpus oil (CRO)-Butanol (BU) alcohol-diesel (D2) on engine performance, combustion, and emission characteristics. Samples investigated were 15% CRO-5%BU-80%D2, 10%CRO-10%BU-80%D2, and diesel fuel (D2) as a baseline. The density, viscosity, cetane number CN, and contents of carbon, hydrogen, and oxygen were measured according to ASTM standards. A four cylinder turbocharged direct injection (TDI) diesel engine was used for the tests. It was observed that brake specific energy consumption (BSEC) of blends was found to be high when compared with that of D2 fuel. Butanol containing blends show peak cylinder pressure and heat release rate comparable to that of D2 on higher engine loads. Carbon dioxide (CO2) and smoke emissions of the BU blends were lower in comparison to D2 fuel [8].

Diana Hernandez, et.al In this work, the liquid phase obtained during the catalytic glycerol decomposition at 400°C using a basic catalyst was characterized by GC and GC–MS. This phase is constituted mostly by highly oxygenated compounds of known energetic use. After a drying process, the effect of the glycerol condensates as an additive in diesel–biodiesel (B5) engines at the 0.2% (v/v) concentration was evaluated. The physical properties of the fuel and the mechanic, thermodynamic, and environmental performance of the stationary diesel engine were analyzed in the current study. The presence of the additive decreased the pour point of diesel and the amount of particulate matter generated during combustion [9].

2. EXPERIMENTAL SETUP

The performance tests were carried on a single cylinder, four strokes and water cooled, kirloskar TV 1 diesel engine Fig 1. The engine was directly coupled to an eddy current dynamometer. The dynamometer was interfaced to a control panel. The engine was run at a constant speed of 1500 rpm. The emissions like HC, CO, NOx, were measured in the AVL exhaust gas analyzer and smoke density was measured by AVL smoke meter. The exhaust gas temperature was measured using thermo couple. Using AVL combustion analyzer the combustion parameter such as cylinder pressure, and heat release were analyzed with diesel as a prime component and kriya bio additives 1ml, 1.5ml, 2ml, 2.5ml, 3ml per liter respectively. The engine specifications are shown in table 1.

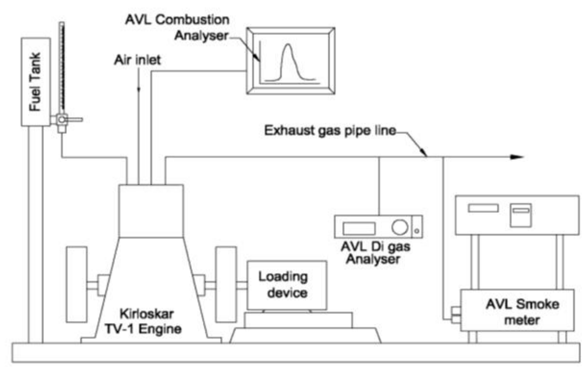

Fig 1 Test Engine

Table 1 Engine Specifications

Type	Vertical inline diesel engine, 4 stroke, water cooled
No of cylinder	Single cylinder
Bore × Stroke	87.5 mm × 110 mm
Compression ratio	17.5:1
Brake power	5.2 kW
Speed	1500 rpm
Dynamometer	Eddy current

Ignition system	Compression Ignition
Ignition timing	23° bTDC (rated)
Injection pressure	220 kgf/cm^2

3. RESULTS AND DISCUSSION

3.1 Performance Characteristics

3.1.1 Specific Fuel Consumption

The variation of specific fuel consumption with brake power for various ratios of kriya additive operation and diesel is depicted in Fig. 2. It can be observed that the specific fuel consumption in kriya operation is higher when compared to that of diesel operation. This is due to low heating value and high viscosity of bio additive compared to neat diesel that result in making more heterogeneity in air fuel mixture resulting in increase in specific fuel consumption. However this can be offset by increasing the fuel injection pressure.

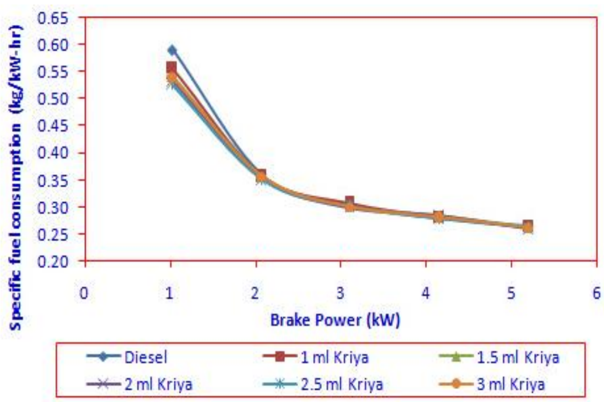

Fig 2 Specific fuel consumption Vs Brake power

3.1.2 Break Thermal Efficiency

The variation of brake thermal efficiency with brake power for kriya operation and diesel is presented in Fig. 3. In all cases, it increased with increase in load. This was due to reduction in heat loss and increase in power with increase in load. The maximum thermal efficiency for 2 ml kriya additive is higher than that of diesel. This blend of 2ml also gave minimum specific fuel consumption. Hence, this blend was selected as optimum blend for further investigations and long-term operation. Based on the results it can be concluded that the performance of the engine with kriya additive blends is comparable to that with diesel, in terms of brake thermal efficiency.

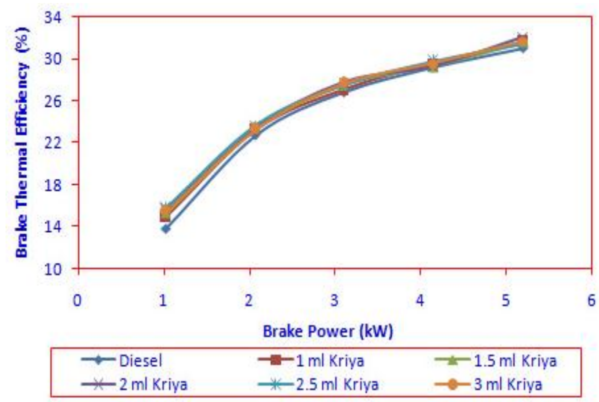

Fig 3 Brake thermal Efficiency Vs Brake power

3.2 Emission Characteristics

3.2.1 Smoke Density

Fig. 4 shows the variation in the smoke intensity with brake power for kriya additive operation and diesel. Smoke emissions are attributed to either fuel–air mixture that is too lean to auto ignite or to support flame propagation, or fuel–air mixture that is too rich to ignite. It can be observed that the production of smoke for kriya additive operation is lesser at all the loads compared to that of diesel operation.

3.2.2 Oxides of Nitrogen

The variation in NOx concentration with brake power for kriya additive and diesel is shown in Fig. 5. The formation of NOx in the cylinder depends on the engine in-cylinder temperature and the rate of combustion. The two most important factors in determining the NOx formation by the combustion process are stoichiometric air fuel ratio and the flame temperature. It can be observed that the formation of NOx for kriya operation is lower when compared to that of diesel operation. This is due to the decrease in in-cylinder temperature, which is reflected in lesser exhaust gas temperature.

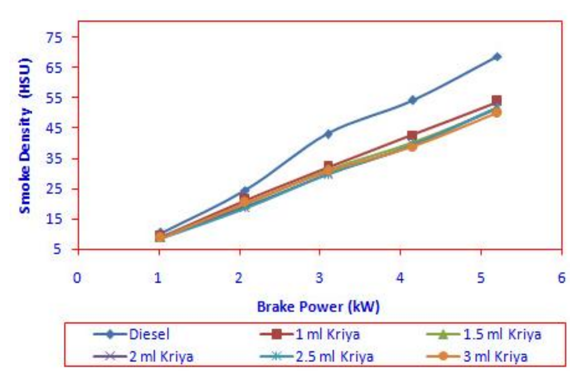

Fig 4 smoke density Vs Brake power

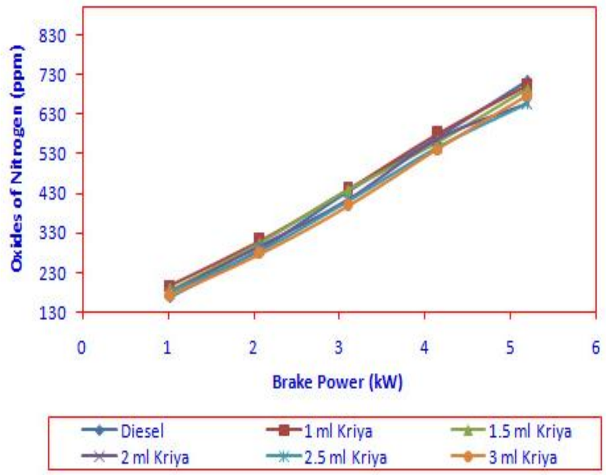

Fig 5 Oxide of Nitrogen Vs Brake power

3.2.3 Hydrocarbon

The variation of hydrocarbon (HC) emission with brake power for kriya additive operation and diesel is shown in Fig 6. It can be observed that the formation of HC for kriya operation is lower compared to that of diesel operation. This is believed to be due to the presence of oxygen in the fuel, which promotes the combustion process. The incomplete combustion of hydrocarbons due to several reasons may be emitted as unburnt Hydrocarbon from an engine. As kriya contains oxygen in the structure itself, so it is believed to enhance the combustion.

3.2.4 Carbon Monoxide

Variation of CO emissions with engine loading for different fuel is compared in Fig 7. These lower CO emissions of kriya additive all blends may be due to their more complete oxidation as compared to diesel. Some of the CO produced during combustion of bio additive might have converted into CO_2 by taking up the extra oxygen molecule present in the bio additive chain and thus reduced CO formation. It can be observed from Fig. 7 that the CO initially decreased with load and latter increased sharply up to full load. This trend was observed for all the fuel blends tested. Initially, at no load condition, cylinder temperature might be too low, which increase with loading due to more fuel injected inside the cylinder. At elevated temperature, performance of the engine improved with relatively better burning of the fuel resulting in decreased CO.

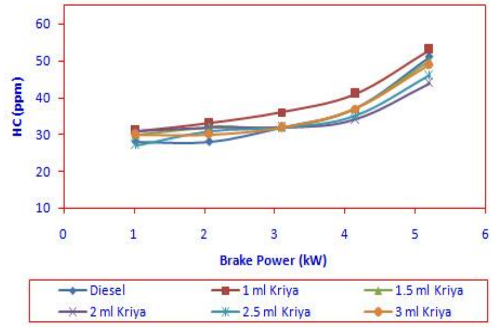

Fig 6 Hydrocarbon Vs Brake power

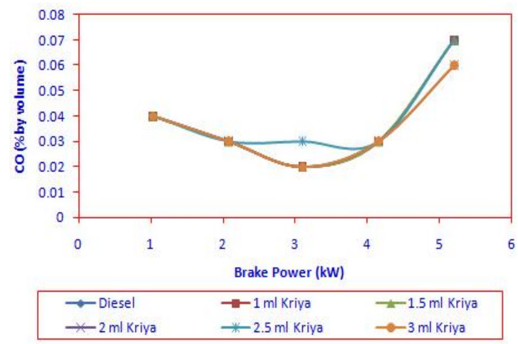

Fig 7 CO Vs Brake power

3.3 Combustion Parameter

3.3.1 Cylinder Pressure

Cylinder pressure at different loads is depicted in Fig. 8. At a full load condition, the maximum peak cylinder pressure was found to be 69.714 bar at 7degree Crank angle with diesel and 69.446 bar at 7 degree crank angle with 2ml kriya additive. This is due to complete combustion inside the cylinder. Complete combustion depends on fuel–air mixing to a large extent. Diesel indicates a slightly higher peak cylinder pressure than bio additive; this may also be caused by its density which is proportional to its bulk modulus. Another reason may be the oxygen-fuel mixing, which is more efficient in fuel that contains intrinsic oxygen.

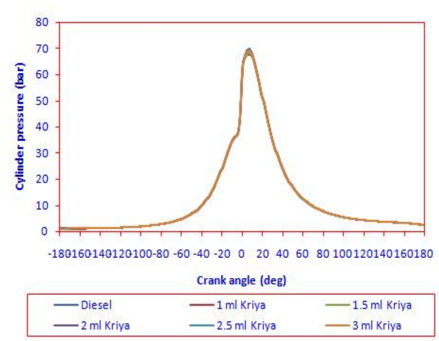

Fig 8 Cylinder Pressure Vs Crank angle

3.3.2 Heat Release Rate

Fig 9 shows the heat release rate against crank angle, it is inferred that heat release rate increases with the load diesel has higher heat release rate when compared with bio additive. Fuel blends follow a trend similar to diesel fuel: that the peak heat release values increase as the load increases. This may be caused by high temperature and high cylinder pressure, better fuel–air mixing, and higher flame velocity associated with higher loads. It is evident that the blends record a slightly early start of combustion in the heat release rate at the premixed combustion period.

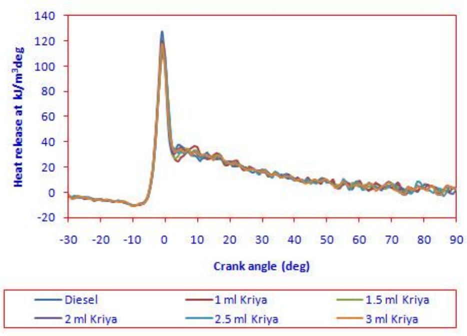

Fig 9 Heat release rate Vs Crank angle

4. CONCLUSION

This experimental investigation compares the performance, combustion and emissions of bio additive and diesel. All tests were performed on a single cylinder, water cold direct-injection diesel engine at various engine loads. Based on these experiments, the following conclusions can be drawn:

- The oxygenated molecular structure and its high oxygen content play a significant role in the mechanism responsible for the performance of these fuel blends with bio-additives and decreasing emissions.
- NOx emission was lower in bio additive compare to diesel.
- Smoke reduced for bio-additive concentrations.
- While comparing all the bio additives it was observed that heat release rate was reduced for all bio additive concentration, compared with diesel.

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