International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 11 | Nov 2022 www.irjet.net p-ISSN: 2395-0072

Effect of Biodiesel Blend on a Zirconium Nano-Coated Diesel Engine

[1]K. Leela Dhanush Naidu, [2]Dr.S.Ganesan

[1]Student, Dept. Of Mechanical Engineering, Sathyabama Institute Of Science and Technology, Chennai, India
[2]Department of Mechanical Engineering, Sathyabama Institute Of Science and Technology, Chennai, India

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Abstract - *All living things are adversely affected by pollution, which is a worldwide issue. Minimizing auto emissions is crucial since it pollutes the atmosphere. Several studies found several approaches to lessen pollution. In this study, clean diesel engines without any biodiesel blend are contrasted with diesel engines that have biodiesel percentages of 20%, 40%, and 60%. The engine features 24 degrees before TDC injection timing and 220 bar designed pressure. A 500 mm thick piston head is used. Zirconium oxide serves as the foundation layer for constant-speed diesel engines. We measured the emissions from on-road diesel engines. SFC and NOx levels are affected under all load conditions. When contrasted with other blend fuel proportions, the test engine with B60 had the highest CO emission. Due to its lower viscosity and higher heating, clean diesel fuel reduces CO.*

Since the ceramic-coated engine acts as an insulator and the test fuels completely burn inside the cylinder, raising its exhaust emission gas temperatures, pure diesel fuel has a high NOx emission. According to the findings of the experimental tests, B20 generates more emissions than the other test fuels. Because biofuels contain more oxygen, they cause the temperature of exhaust gasses to rise, which causes NOx levels to rise from idle to full engine load.

Key Words: **Nano Coatings, Zirconium, Piston Head, Fuel Injectors, Performance.**

1. INTRODUCTION

By using ceramic coating processes, efforts are being undertaken to lower the quantity of fuel consumed and also the volume of gas pollution created by diesel engines. uses for engines had a variety of coating procedures to improve the engines' performance [7]. Additionally, ceramic coatings increase the thermal efficiency of engine components, reduce internal friction, and minimize noise. They did a few extra trials that concentrated on zirconia oxide coating, which has higher melting temperatures than some other contemporary coating materials, even though the major objective of this experiment was to examine the endurance of various coating materials. Due to their exceptional corrosion and erosion resistance, zirconia materials are employed in diesel and turbine blades to assist decrease engine heat loss [2]. A single-cylinder test of an unsealed piston is conducted to seal its cylinder, valves, and piston of a gas engine with ZrO_2 / Al_2O_3 using a plasma thermal spray process in conjunction with ethanol-diesel blended fuel. The coating was 150/150 microns by ZrO_2 / Al_2O_3 on a 150 m-thick Mg-coated piston and a 50 m-thick NiCrAlY[3]. Following the experimental results, the BTE was predicted to have increased, whereas CO_2, NOx & UHC were all predicted to have decreased. CO_2, CO, and UHC emissions over the diesel baseline [4-6].

1.1 Experimental Setup

The test setup utilized for this inquiry is shown in Figure 1. Five hazardous gases found in exhaust emissions are examined using an AVL gas analyzer. It was possible to raise the overall load from 0% to 100% using an eddy current dynamometer. The engine specifications are displayed in table 2.

FIGURE 1.VCR Engine

1.2 Zirconium Oxide

Zirconium oxide is also called Zirconia for its mechanical properties. Even in an IC engine, zirconia can withstand high temperatures. Zirconia coatings are superior to other contemporary coating materials at withstanding thermal shock in addition to having a higher melting point. Internal engine heat loss is reduced by a cylinder head with aero-foil turbine blades and Zirconia-coated materials. During the transition phase, a precise volume differential of 10% between monolithic and tetragonal zirconium develops, leading to the discovery of thermal cracks and fractures.

2. Biodiesel Preparation

A biofuel engine running on rubber seed oil (RSO) was put to the test. The seeds were ground and sieved to obtain the raw oil. In India, RSO is a minuscule non-edible oil source. An acre of RSO in India may produce around 150 kilograms of oil annually. There is plenty of light-yellow oil in the seed kernels (Table 1.). There are rumpled rubber seeds that have been esterified using diesel RSO combinations at 20%, 40%, and 60%.

Table -1: Properties of diesel and rubber seeds oil

Property	Diesel	Raw Rubber Seed oil
Calorific value(MJ/kg)	42604	39780
Kinematic viscosity at 40°(mm^2/s)	4.15	4.27
Specific gravity	0.76	0.85
Sulphur content(wt. %)	0.29	-
Moisture content(wt. %)	-	0.41
Iodine value(mg/l2/g oil)	8.5	116.2

Table -2: VCR Engine Specifications

Engine	Kriloskar AV1
Type	4-Stroke Diesel Engine
Bore	87.55 mm
Torque	2.387 Kg-m
Compression Ratio	17.5
Fuel Capacity	6.5 L
Ignition	Direct Injection

2.1 BRAKE THERMAL EFFICIENCY

The variation of BTE under various loads and tests conducted at 220 bar inlet pressure is shown in Figure 2. The BTE value rises as the load changes. At 100% load, the BTE value increased to 29.4%.

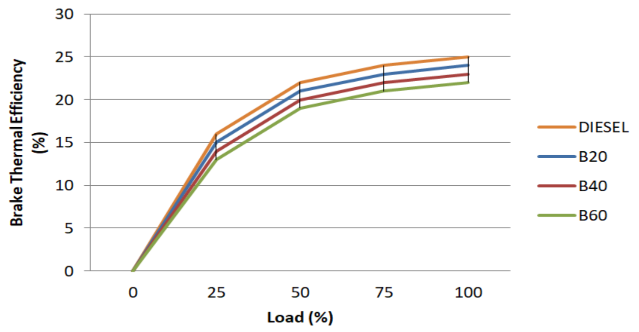

Chart -2: BTE vs Load

The BTE also reduced during the steady rise from lowest to 100% load whenever the biodiesel blend fraction was increased. The BTE for B20 was found to be far closer to that of regular diesel and was further boosted, reaching 23% under 100% load. According to the research, the B60 blend has a 20% optimum BTE under 100% load circumstances. The various engine components' improved spray coatings or insulation raise the temperatures at which fuel burns.[8]

2.2 SPECIFIC FUEL CONSUMPTION

In all engine load circumstances, the BSFC is maintained with a variety of loading conditions for all of the fuel blends and an operating pressure equal to 220 bar (Figure 3). The fuel gets completely oxidized due to better dispersion combustion in the combustion chamber; the overall BSFC is enhanced for all the fuel blends [9].

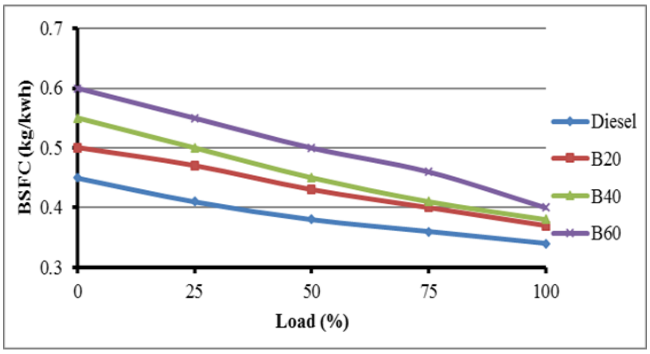

Chart -3: SFC Vs Load

The diesel has a lower BSFC than other bio blends, ranging from 0.43 kg/kW-h-0.36 kg/kW-h. At various loads, the B20 blend uses approximately 0.4 kg/kW-h and 0.5 kg/kW-h more biofuel than diesel. The BSFC, which is equivalent to B20 fuel, varies between 0.42 kg/kW-h and 0.55 kg/kW-h between no load and 50% load. B60 blend emissions fall between 0.61 and 0.48 kg/kW-h. The relevant BSFC is discovered to be lower than the fuel spent without coating due to the Zirconia coating materials offered and the adequate insulation. Because of the partial ceramic thermal coating inside the cylinder piston head, the fuel burnt entirely inside the cylinder, converting a massive quantity of heat energy into productive work [10].

2.3 CARBON MONOXIDE

The change in CO exhaust emissions out of a diesel engine having coated pistons @ 220 bar operating pressure is shown in Figure 4. Absolute diesel discharges less CO than the other examined fuels, spanning between 0.034 % to 0.05 % vs no load & 100%.

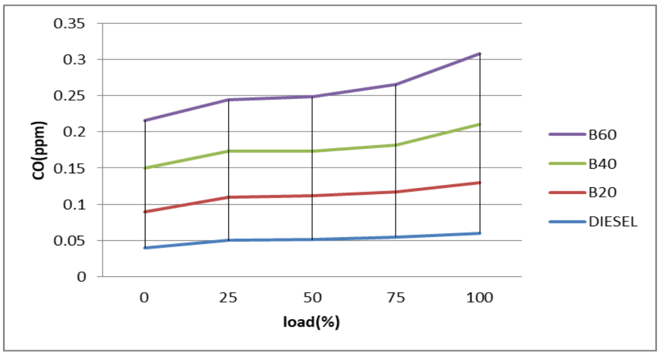

Chart -4: CO Vs Load

2.4 NITRIC OXIDE (NOx)

The fluctuation in NOx values of no load to full load for various biofuel mixtures around 220 bars injection pressure is shown in Figure 5. Utilizing the zirconia coating on the piston head improved combustion efficiency, resulting in lower NOx emissions across the board when compared to pure diesel fuel. Diesel fuel produces NOx emissions that fluctuate between 301 ppm at rest and 1100 ppm at maximum load. NOx levels in B20, B40, and B60 blends are identical and slightly lower than in raw diesel. Whenever the engine load fluctuates, the NOx values for the blends B40 and B60 range between 193 ppm to 1014 ppm and 157 ppm to 1002 ppm, respectively. The NOx from the exhaust gas is also decreased for biodiesel fuels as a result of this phenomenon.

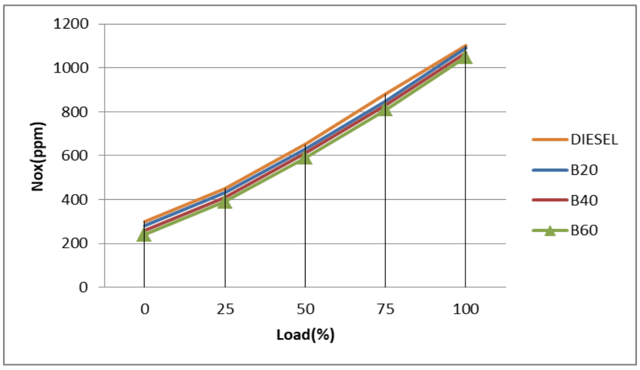

Chart -5: Nox Vs Load

2.5 UNBURNED HYDROCARBON (UHC)

The effect of cylinder pressure on UHC emissions in biodiesel is shown in Figure 6. Since pure diesel has a high heating value, it had the least UHC (15 ppm to 23 ppm). As biofuels are mixed with regular diesel, the amount of UHC emissions increases gradually. UHC levels in B20 biofuel and regular diesel fuel, which range between 23 to 26 ppm, are comparable. So when the exhaust temperature is swiftly raised, UHC production is reduced. Because of the higher combustion temperature, which raises both flows of conduction and the octane number, biodiesel discharges higher UHC than pure diesel. In this investigation, esterified biodiesel substitutes biodiesel in the thermally coated engine used to stop heat loss, and UHC costs less than thermally uncoated diesel fuel. Higher oxygen content in biodiesel promotes more thorough combustion of the biofuel by reducing UVA emissions and improving thermal insulation through the piston head [11-12].

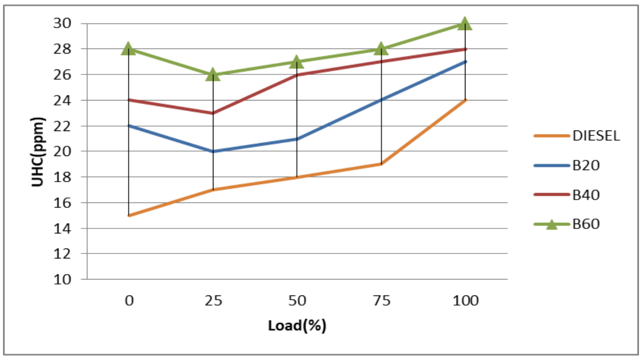

Chart -6: UHC Vs Load

2.6 RESULT AND DISCUSSION

We compared the performance of plain diesel with that of pure diesel and rubber seed oil biofuel mixes. Single-cylinder performance evaluation for BTE and BSFC Nitric oxide (NOx), carbon monoxide (CO), and unburned hydrocarbon emissions have all been measured from this study.

3. CONCLUSIONS

The properties of the exhaust gases and engine performance of the diesel engine with ceramic coating are examined. The piston head is encapsulated with the best nanopowder, zirconium oxide, which improves performance. The findings of the experimental tests are described as follows:

- The BTE for B40 & B60 is quite close to that of gasoline mix B20. The coated engine absorbed the most BTE, which is 25% more than that of pure diesel. When compared to other bio-blends, B20 biodiesel provided the best BTE.
- The result of the experiment revealed the BSFC, which demonstrates that as engine load increases, its fuel-specific consumption gradually decreases. The lowest fuel-specific consumption parameters were taken when using gasoline in ceramic-coated engines, and blend B20 provides the lowest fuel-specific consumption results compared to other proportions.

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