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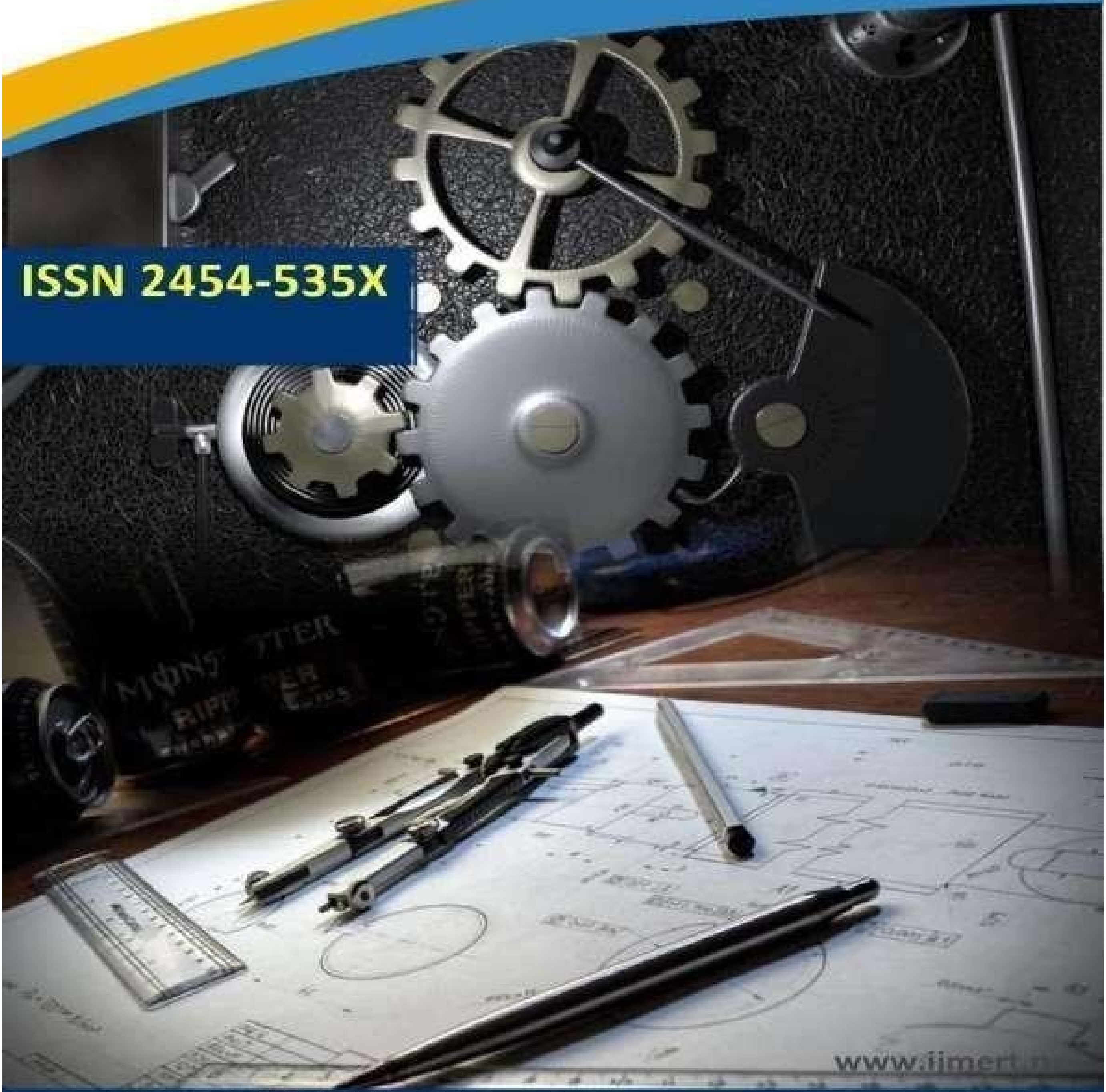

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Using diesel and blends of turmeric leaf oil to reduce emissions and improve the efficiency of variable compression ratio engines

B. Sandeep Reddy

Research Scholar, Department of Mechanical Engineering, UCE(A), Osmania University, Hyderabad, and Lecturer in Mechanical Engineering at GMRP GAJWEL, Telangana.

Dr. Ch. Raja Sekhar

Professor and Head, Department of Mechanical Engineering, UCE(A), Osmania University, Hyderabad, Telangana.

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ABSTRACT

A growing need for renewable energy sources has resulted from research into possible replacement fuels for internal combustion engines. This research examines the effects of using turmeric leaf oil (TLO) as a biofuel in a variable compression ratio (VCR) engine with the goal of increasing efficiency and decreasing exhaust emissions. The experiments used a single-cylinder, four-stroke diesel engine that operated on different compression ratios, from 19.5:1 to 18.5:1, and under different loading situations, from 5 to 9 kg. We measured the brake thermal efficiency, volumetric efficiency, and specific fuel consumption (SFC) of diesel blends with varying amounts of TLO (B50, B60, and B70) to see how well they performed. When the engine load increases, the results show that TLO integration somewhat reduces volumetric efficiency but significantly increases brake thermal efficiency.

Exhaust Emissions, Biofuels, Volumetric Efficiency, Brake Thermal Efficiency, and Variable Compression Ratio (VCR) Engines are some of the keywords in this context.

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1. Introduction

One of our oil-based resources is petroleum diesel, which is naturally converted into biodiesel [1]. Biodiesel, according to its chemical formula, is an ester of mono-alkyl fatty acids made from methyl ester fatty acids, which may be derived from either animal or human fats [2]. Biodiesel may be made from a variety of materials. These nutrients include waste oils, animal fats (such regular milk), and common vegetable oils (including soybean, cottonseed, palm, peanut, canola, sunflower, herring, and coconut). The choice of cuisine is determined by the well-known geographical figure. Lipids include oils and fats. Animals and plants both contain lipids. There are two main types of oils: edible and inedible. Fats come from animals, whereas oils are plant-based. Triacylglycerols, the main component of animal oils and fats, are made up of three fatty acid groups. One molecule of glycerol connects these trimesters. Triplicity of variation between oil types is seen in the TG fatty acid (FA) machinery. The fatty acid composition of the source oil or animal fat is reflected in the different triglycerides. The fuel's properties are affected by the fatty acids' physicochemical properties. Triglycerides and an alcohol, most often methanol, undergo a transesterification process with a catalyst to produce biodiesel. Monoglyceride and glycerol are the end products of each cycle, with one molecule of glycerol freed from the fatty ester at each stage [3]. At the end of the process, for every mole of triglyceride converted, there will be 3 moles of astral alkyl and 1 mole of glycerol as the net yield. The Nim family includes the Meliaceae plant. Its original habitats include the Asian countries of Japan, Indonesia, Sri Lanka, Burma, and India. Some environments may be ideal for its growth, such as

Soils could be clay-like, acidic, sandy, rocky, deep, salty, or fertile [4]. This tree is rather large, with a potential height of 15–40 meters. The advantages become most apparent after the age of fifteen. A 150-200 year lifetime is typical. The seed contains 20–30% oil, but the nucleus, which is greenish–brown in color, has 40–50% oil [5,6,7]. Research has shown that capillary oil may be dissolved for biodiesel using the basic transesterification technique [8]. The significant byproduct known as rice bran oil is extracted from the brown rice kernel's outermost layer. From sixteen to thirty-two percent by weight is the oil content [9,10]. The majority of rice bran oil, about 60–70%, is not edible. Compared to other edible oils like sunflower, corn, or soybean, rice bran oil doesn't get nearly as much love. Commercial uses account for the most of

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the oil production, however rice bran is still used as animal feed. If harvested for its oil, the world's rice bran might have produced more than 8 million metric tons of crude rice bran oil, according to reports. Refining crude rice bran oil is challenging because of the high levels of fatty acids and non-convertible materials it contains [11]. Among the many engine types available, the variable compression ratio engine is by far the most common. Diesel fuel is used. In addition, researchers are now facing issues when it comes to running the engine with alternative fuels, namely fossil fuels, since these conventional resources are becoming more scarce. Performance parameters such as braking thermal efficiency, volumetric efficiency, and exhaust emissions are evaluated in this work by using turmeric leaf oil (TLO) as a biofuel in a variable compression ratio (VCR) engine with conventional gasoline at varied blend percentages [12,13,14,15]. In this case, to run engines that use alternative fuels. how well the VCR engine ran on different amounts of biofuel, namely pure turmeric leaf oil (TLO), in addition to conventional diesel fuel [16].

2. EXPERIMENTAL PROCEDURE

To check the engine working condition is good or not and then coolant is extended to required criteria to start the engine without load mode up to 10 minutes, that is ideal state. To pour the biofuel in the fuel tank to start the engine and to estimate the performance and emission level of the engine with different blends of biofuel and different load state with blends.The performance of an engine is evaluated using several key parameters, which provide insights into its efficiency and effectiveness. These parameters include Brake Power (B.P.), Brake Mean Effective Pressure (BMEP), Mechanical Efficiency (η_{mech}), Brake Thermal Efficiency (η_{bth}), Brake Specific Fuel Consumption (BSFC), Volumetric Efficiency (η_{vol}), and Emission Characteristics. Each parameter plays a crucial role in assessing the engine's operational capabilities and environmental impact. Brake Power (B.P.) represents the power available at the crankshaft of an engine. It is the actual output power in internal combustion engines and is given by:

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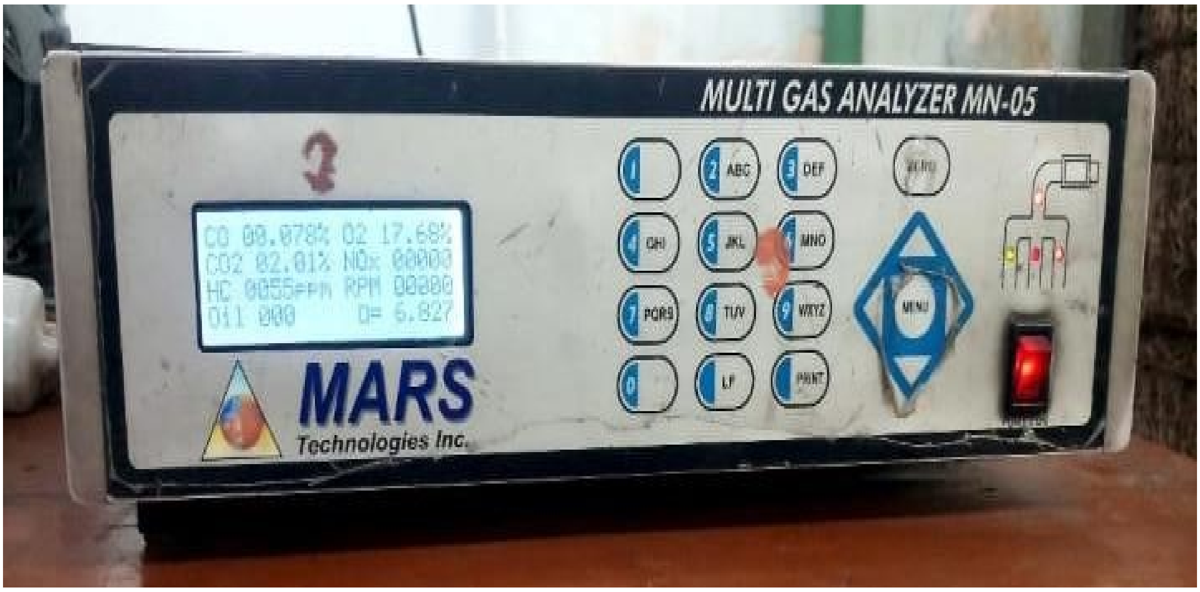

Figure 1: Multi Gas Analyzer

One approach to quantify the amount of heat that exhaust gases remove is with the help of an exhaust gas calorimeter. The device's inner tube carries the exhaust gasses, while the outside jacket is responsible for circulating water. To determine the amount of heat that the exhaust gases carried, the calorimeter measures the difference in temperature between their input and output. Exhaust gas heat energy loss may be precisely calculated with the use of a rotameter, which monitors the volume of water circulation, and thermocouples, which record the temperatures.

The engine performance parameters are

- Brake Thermal Efficiency.
- Volumetric efficiency.

Types of Emissions

- Carbon Monoxide (CO)
- Hydrocarbons (HC)
- Nitrogen Oxide (NO_X)
- Carbon Dioxide (CO_2)

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Before starting the engine, all nuts and bolts were thoroughly checked to ensure proper fastening. Care was taken to maintain the correct oil level in the engine. The engine was consistently attended to, ensuring the cooling water supply to both the engine and dynamometer remained uninterrupted, even during power outages. The fuel tank and fuel lines were cleaned thoroughly. Additionally, it was confirmed that the water supply was active before starting the engine. Sensitive instruments, such as the pressure crank angle sensor and other sensors, were handled with the utmost care.

3. RESULTS AND DISCUSSIONS

The experimental analysis of the variable compression ratio engine using different blends of turmeric leaf oil (B50, B60, and B70) at a compression ratio (CR) of 19.5:1 revealed notable trends in engine performance and efficiency. For the B50 blend, the results showed that as the load increased, both the brake thermal efficiency (BTE) and mechanical efficiency improved gradually. Specifically, the BTE increased, while volumetric efficiency exhibited a slight decline. The specific fuel consumption (SFC) decreased with increasing load, dropping from 0.5722 kg/kWh to 0.3198 kg/kWh. Similarly, the B60 blend demonstrated a comparable pattern: with rising load, BTE and mechanical efficiency continued to rise, and volumetric efficiency decreased slightly. The SFC for B60 also reduced with load, from 0.579 kg/kWh to 0.3013 kg/kWh. For the B70 blend, the trend was consistent with the previous blends, showing an increase in BTE and mechanical efficiency with load, while volumetric efficiency decreased slightly.

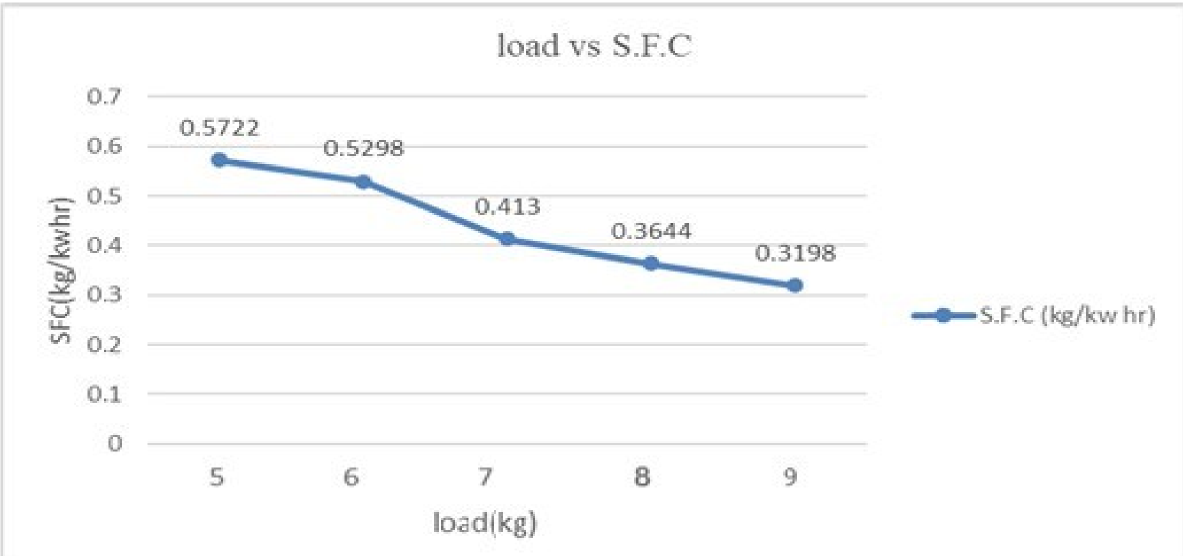

Figure 2: SFC w.r.t Load on VCR Engine for B70 Blend at CR 19.5:1

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Notably, the SFC for B70 experienced a more substantial decrease, from 0.627 kg/kWh to 0.254 kg/kWh. When comparing the different blends (B50, B60, and B70) based on their brake thermal efficiency, it was observed that B70 exhibited the highest BTE, increasing from 22.51% to 39.29%, outperforming the other blends. Further more, when analyzing volumetric efficiency across the blends, B70 again showed superior performance with an initial value of 68.18%, which increased to 69.71% before slightly decreasing to 64.9%.At a higher compression ratio of 18.5:1, B70 continued to demonstrate the best brake thermal efficiency among the blends, with BTE rising from 17.56% to 27.76%, indicating that B70 is the most effective blend in enhancing the engine's performance under varying loads. The SFC decreases with an increasing load because the engine or power plant operates more efficiently, with a larger proportion of the fuel contributing to useful power output, reducing the overall fuel consumption per unit of power produced.

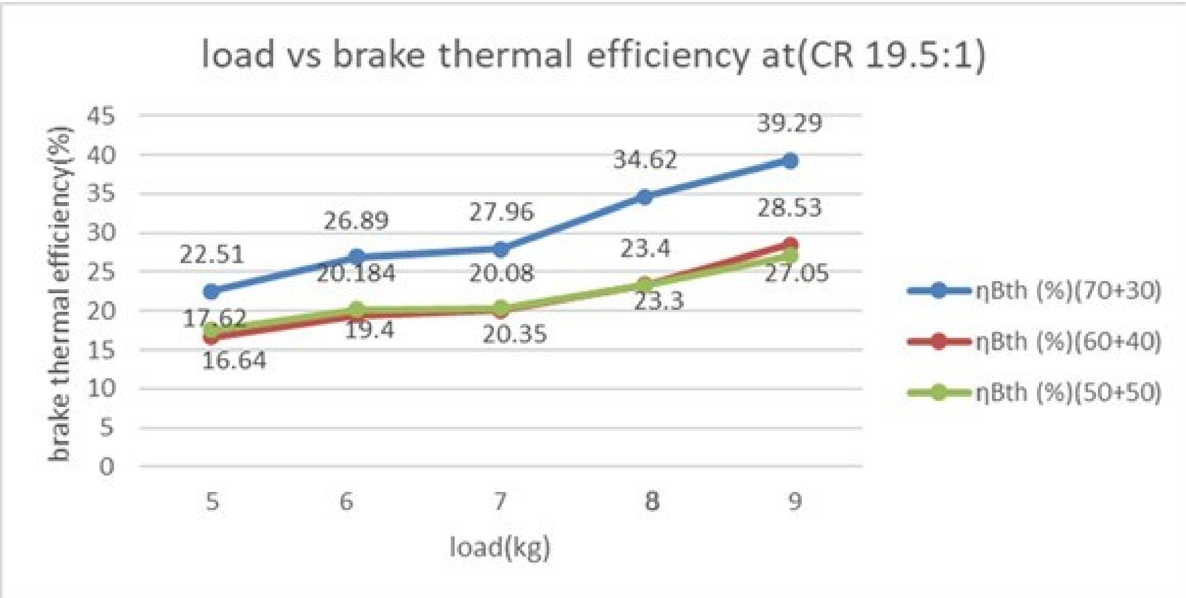

Figure 3: Brake thermal efficiency w.r.t Load on VCR Engine for B70 Blend at CR 19.5:1

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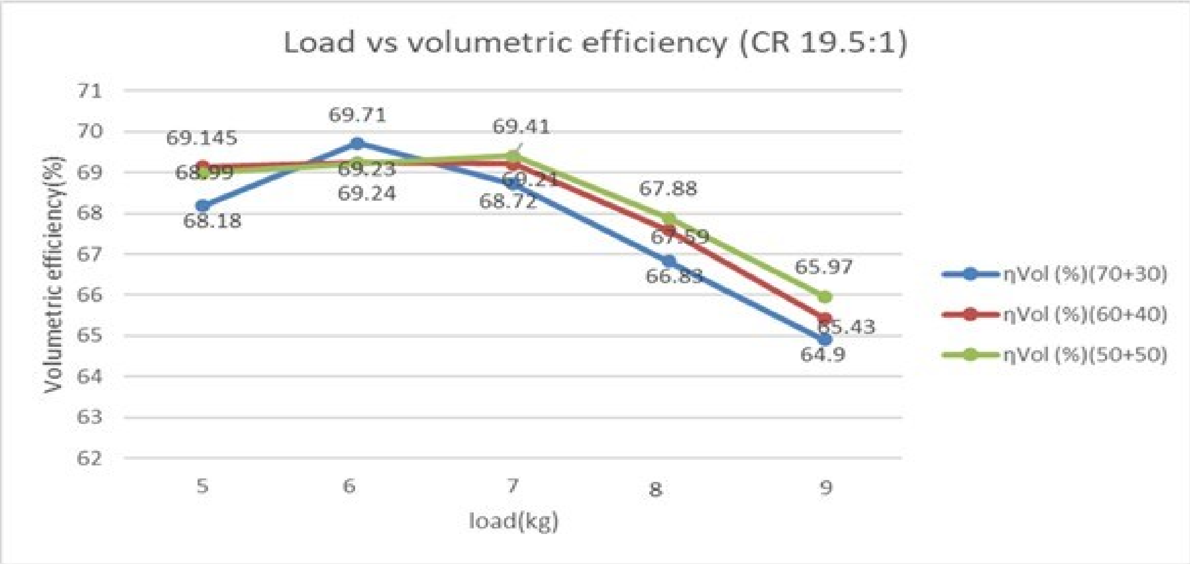

Figure 4: Volumetric efficiency w.r.t Load on VCR Engine for B70 Blend at CR 19.5:1

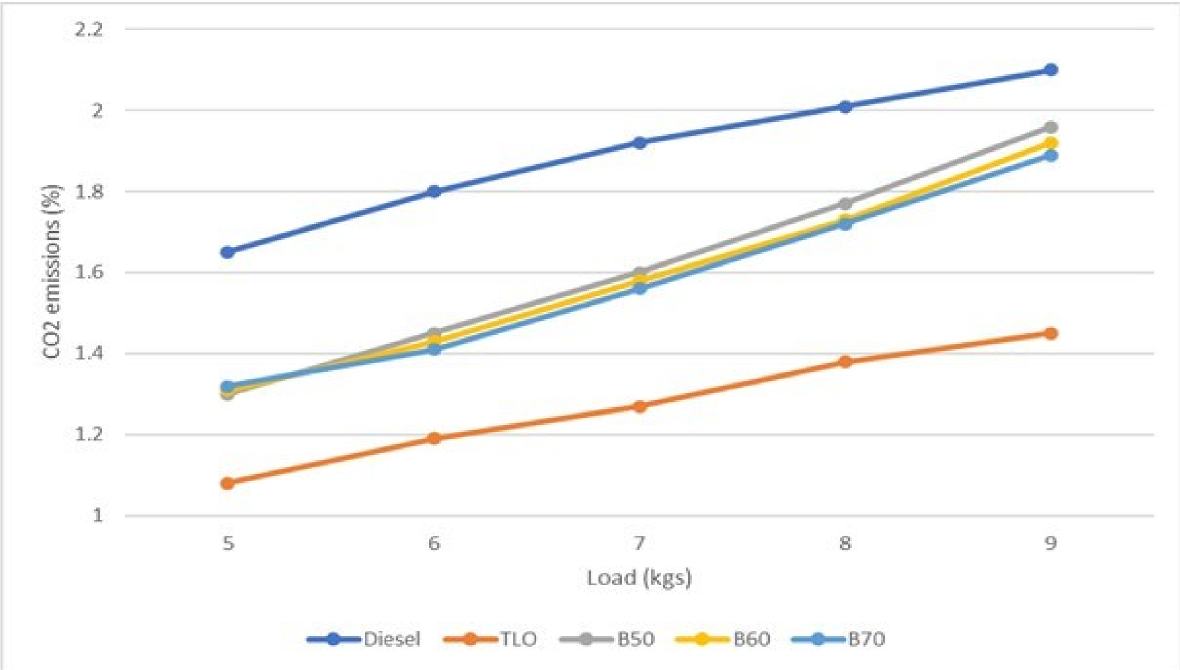

Figure 5: % of CO_2 emission from VCR engine for different fuels

Figure 5 illustrates the carbon dioxide emissions of several biodiesel mixes at varying loads for 19.5:1 compression ratio. The carbon dioxide emissions of B70, and diesel are low compare across all loads and various blends. CO2 emissions significantly decrease at a compression ratio of 19.5:1 across all fuel blends. This results from an elevation in gas temperature, full combustion, and the oxygen content in the turmeric leaf oil.

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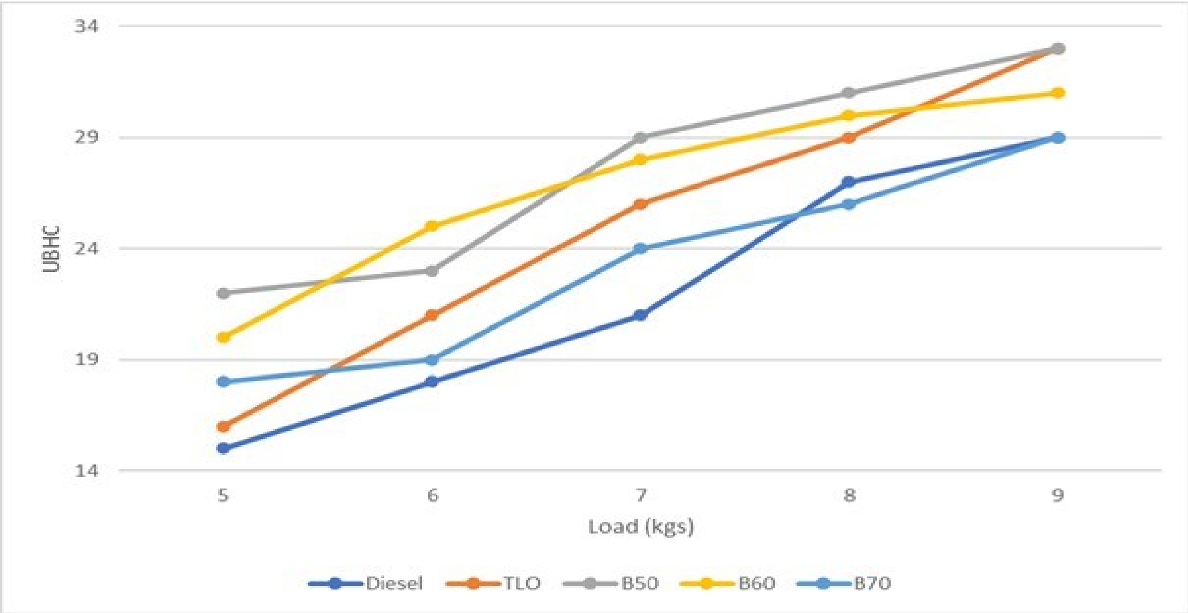

Figure 6: % of UBHC emission from VCR engine for different fuels

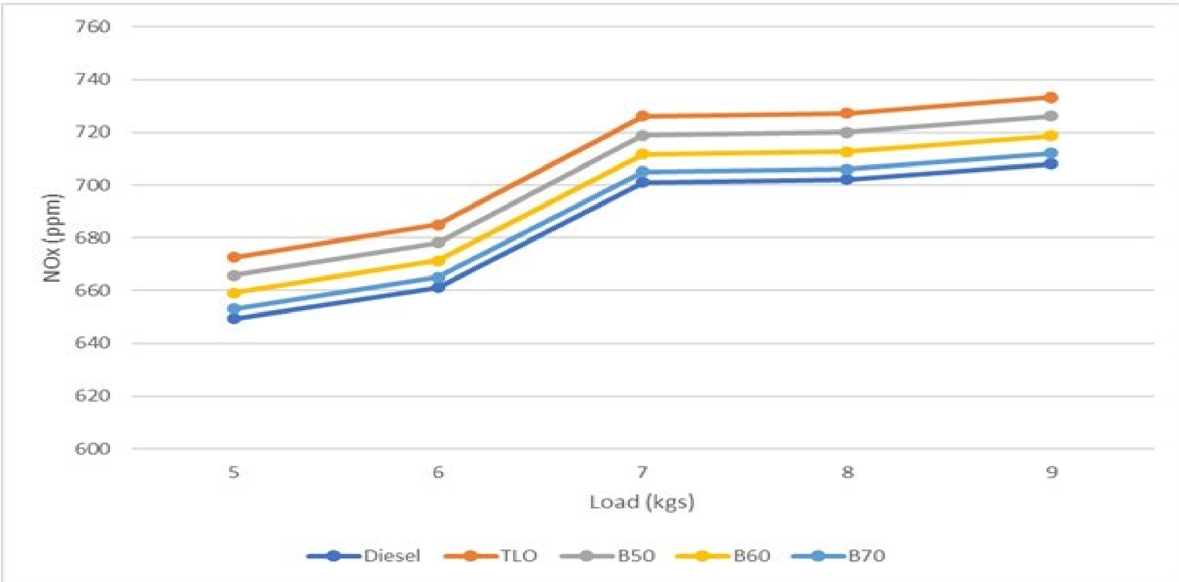

Figure 7: % NOx in VCR engine for different fuels

Figure 7 illustrates the nitrogen oxide emissions corresponding to 19.5:1 compression ratios at various loads and biodiesel mixtures. The NOx emissions of B70 are comparable to those of normal diesel across all loads. An elevation in biodiesel concentration, load, and compression ratio extends the ignition delay of biodiesel. The energy content of biodiesel facilitates combustion and elevates cylinder temperature at increased compression ratios. The findings in figure 6 indicate that the hydrocarbon emissions of Diesel, TLO and their blends

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B50, B60 & B70. B70 are comparable to those of diesel at a compression ratio of 19.5:1 when compare the reading with all other blends and pure TLO.

4. CONCLUSIONS

Significant increases in engine performance and fuel economy were shown in the research that used turmeric leaf oil as a fuel additive to reduce exhaust emissions and enhance efficiency in variable compression ratio engines. When it came to brake thermal efficiency and volumetric efficiency, the trial findings showed that B70 (70% turmeric leaf oil) was the best of the blends tested, regardless of the load or compression ratio. B50 and B60 also fared poorly. At higher compression ratios in particular, B70 showed a more significant decrease in specific fuel consumption and improved brake thermal efficiency. These results provide further evidence that turmeric leaf oil, especially in the B70 mix, is a promising bio-additive that improves engine performance and helps lower fuel consumption. In light of this, turmeric leaf oil may be a viable alternative fuel additive that is both environmentally safe and effective at enhancing engine performance with no negative impact on emissions.

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