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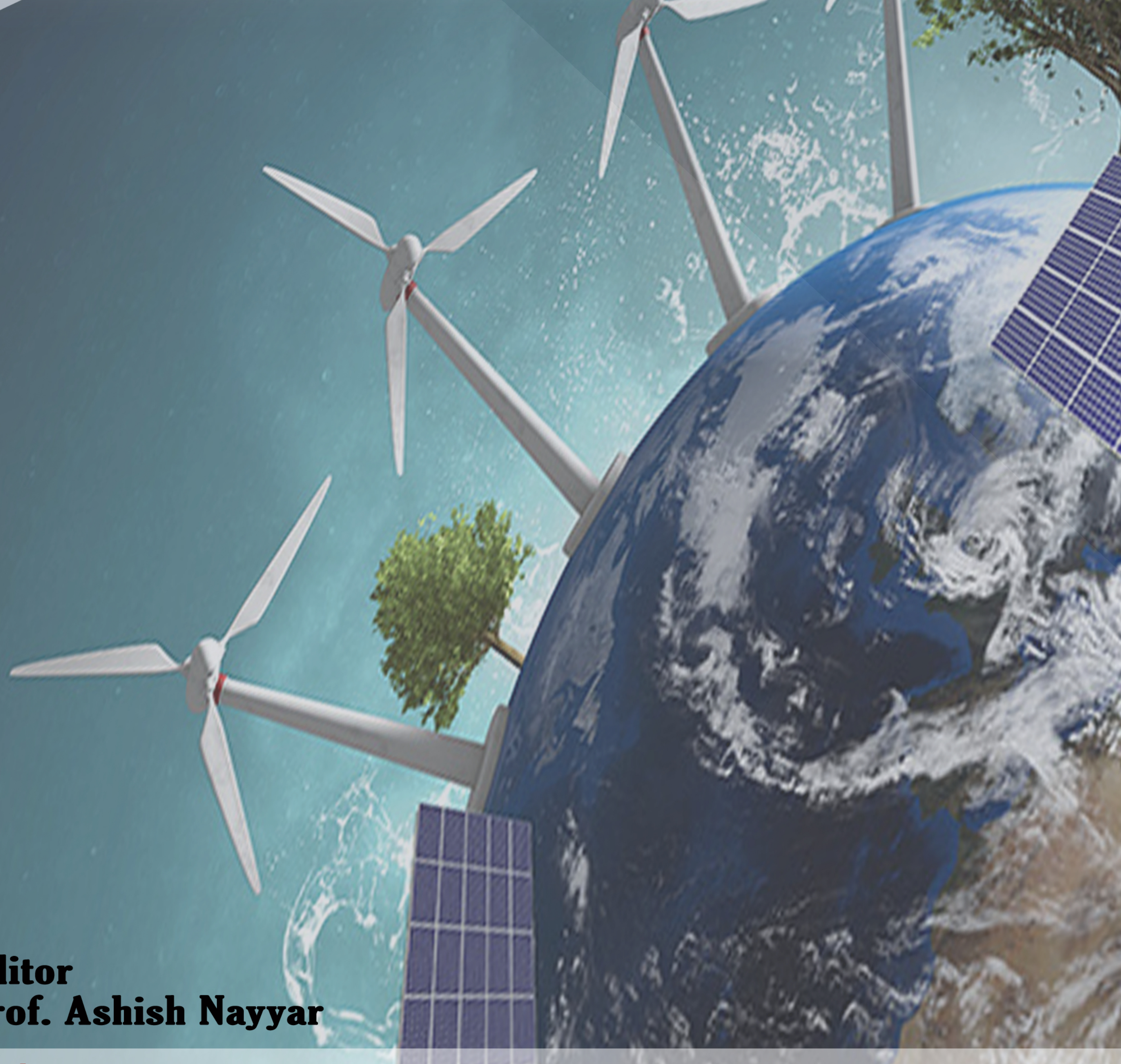

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INVESTIGATION OF THE EFFECTS OF TERNARY DIESEL-ADDITIVES BLENDS ON VCR DIESEL ENGINE

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Abstract

This study investigates the effects of diesel- n-butanol- nitromethane replacing conventional diesel fuels to enable clean combustion of a modern CI engine. The engine experiments are conducted with diesel- n-butanol- nitromethane blends to examine the combustion characteristics of CI engine. Many research works have been done out to improve combustion by different methods. Out of those, the use of alternative fuels and additives seems to be a potential solution to improve combustion in the current scenario. n-butanol and nitromethane were selected as additives to diesel by literature review, physical and chemical properties, availability in the market and their cost. In the first phase, experiments were performed to optimize n-butanol-diesel blend on an existing engine, and in the second phase, nitromethane was blended in the optimum n-butanol-diesel blend. A single cylinder four stroke, water cooled engine (Kirloskar TV1) has been used for experimentation. The results of performance for NM-n-butanol-diesel blends have been drawn and analyzed. An increment of 9.81% in BTE has been observed in comparison to diesel at rated power.

Keywords: Diesel, n-butanol, nitromethane, Performance.

INTRODUCTION

Diesel engines are major contributors in transportation automobile and agriculture sector at present all over the world [1]. One major area of research related to this field is alternative fuels for enhancing the performance. In addition to this, use of additives with diesel is the current issue of research. Alcohols and oxygenated additives present such options with their suitability for blending in diesel for existing engines [2-4]. The blending of alcohol increases the availability of oxygen in the combustion chamber due to which combustion characteristics improve. In this research work, n-butanol (B) and nitromethane (NM) were blended with diesel successively to improve the performance [5-7]. n-butanol (C4H9OH) was chosen as an additive with diesel due to its higher heating value, higher cetane number, good miscibility with diesel and being less hydrophilic in comparison to methanol and ethanol. Nitromethane (CH3NO2) was taken as a nitrogenated additive to improve oxygen content and performance of n-butanol diesel blend. The oxygen content of nitromethane is fairly high, and the higher presence of oxygen in its molecular structure provides better combustion efficiency [8-10]. The baseline data was generated with diesel on normal settings of the engine specified by the manufacturer. By baseline experiments with diesel, 18.5:1 compression ratio, 210 bar injection pressure and 23º before top dead centre (btdc) injection timing were used as optimum engine parameters. After selection of suitable engine parameters, tests were conducted for optimization of blended fuel for performance and emissions. The properties of fuel and additives are shown in Table 1 [10-16].

Table 1: Properties of fuel and additives used for experimentation

Properties	Diesel	n-butanol	Nitromethane
Molecular Formula	C10H20–C15H28	C4H9OH	CH3NO2
Molecular Weight	170	74	61.04
Density (kg/m3)(20 °C)	837	810	1138
Boiling Point (°C)	180-360	118	100-103
Flash Point (°C)	60-80	35	35
Auto ignition Temperature (°C)	315	385	418
Lower heating value (MJ/kg)	43	33.1	10.52
Latent heat of Vaporization (kJ/kg)	250	585	561
Cetane Number	50	25	NA
Viscosity (40 °C) cSt	4.8	2.26	4.8
Oxygen content (wt. %)	0	21.6	52.4
Carbon content (wt. %)	85-88	64.82	19.6
Hydrogen content (wt. %)	12-15	27	4.9

EXPERIMENTAL SETUP

A kirloskar made variable compression ratio diesel engine was used for test runs. It consists of a test-bed, having a diesel engine, eddy current dynamometer, fuel tank, air box, computerized data acquisition panel having controls and displays for different thermocouples, speed sensor, and flow meters. Fuel supply was measured using a load cell. The schematic layout of the experimental setup for the present study is shown in Figure 1. The specifications of the instruments are shown in Table 2.

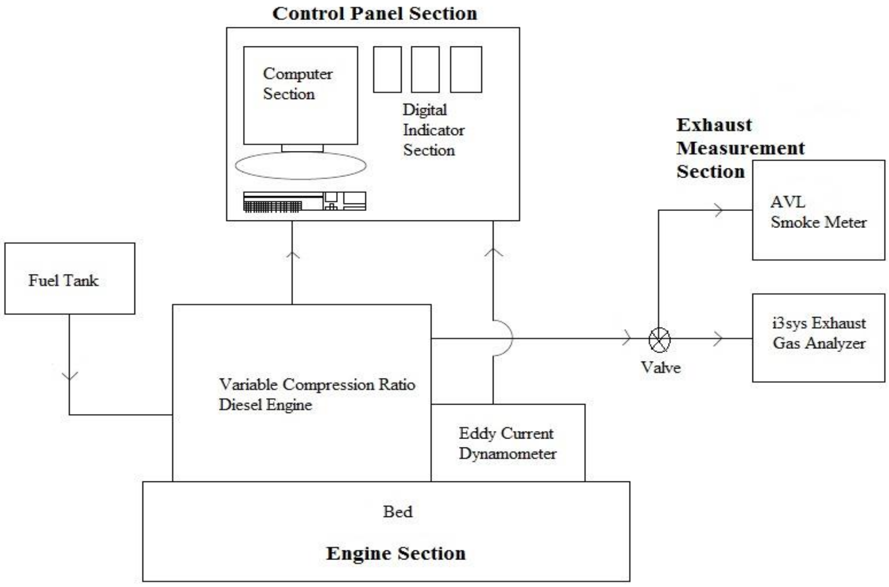

Figure 1 Schematic layout of the experimental setup

Table 2: Specifications of Test Engine

Description	**Specifications**
Make	Kirloskar TV1
Type	Vertical/Single acting, totally enclosed, high speed compression ignition diesel engine.
Power	3.7 kW
Rated Speed	1500 rev/min (Governed Speed)
Number of Cylinders	1 cylinder
Compression Ratio	16.5:1 to 19.5:1 (Variable Compression Ratio)
Bore	80.0 mm
Stroke	110 mm
Fuel Tank Range	0-5000gms
Fuel Rate Range	0-10kg/hrs
Method of Loading	Eddy Current Dynamometer
Air Tank Size (mm)	90(H) x 195(W) x 240(D)
Orifice Size (mm)	20 mm
Air Rate Range	0-50.0 m3/ hrs
Temperature Range	0-800°C
Pressure Range	0-200.0 bar of CP
DI Pressure Range	0-2000bar

RESULTS AND DISCUSSION

3.1 Selection of percentage of n-butanol in the blend:

In the first phase, experiments were conducted using blends of butanol 10%, 20% and 30% by volume in diesel respectively. Performance characteristics were drawn and compared to determine the suitable percentage of butanol.

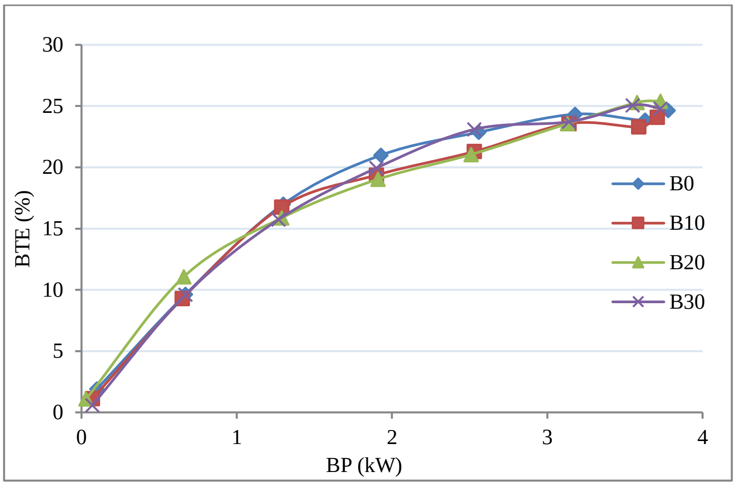

Figure 2 Variation in BTE for n-butanol diesel blends

Figure 2 shows the brake thermal efficiency (BTE) characteristic. From these curves, it was observed that there was no significant variation in engine performance because of n-butanol blending. However, B20 gave the best results among the tested blends at rated power. Therefore, B20 was selected as the optimal binary blend for further experimentation with the addition of a secondary additive.

In the present study nitromethane has been taken as a secondary additive with n-butanol-diesel blends to further improve the engine performance. Nitromethane (NM) was added to a range of 1-3% in n-butanol-diesel blends on the volume basis and denoted as B20NM1, B20NM2 and B20NM3 respectively.

3.2 Selection of percentage of nitromethane in B20 blend

The observations were taken for B20NM1, B20NM2 and B20NM3 and observations were presented in the form of curves. The performance curves for NM-n-butanol-diesel blends are shown in figure 3.

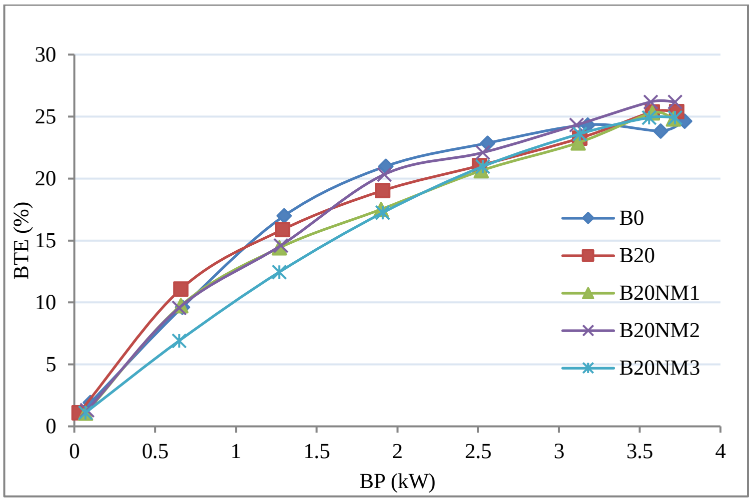

Figure 3 Variation in BTE for NM-n-butanol diesel blends

Figure 3 represents the engine performance characteristics for NM-n-butanol-diesel blends in terms of BTE. With the addition of nitromethane, the oxygen content of the blend improved so that the combustion efficiency. For B20NM2 BTE was maximum in tested group. At rated power, BTE was observed 5.28%, 9.81% and 4.49% higher for B20NM1, B20NM2 and B20NM3 respectively when compared with neat diesel at rated power. With these results from experiments, it was found that with B20 the performance of the engine was improved in comparison to diesel.

CONCLUSIONS

1. The brake thermal efficiency for B20 was increased up to 6% in comparison to diesel.
2. When NM-n-butanol-diesel blends were tested, B20NM2 appears as potential fuel for existing diesel engine. With B20NM2 the BTE was improved by 9.81% in comparison to diesel.
3. It is concluded that ternary blend B20NM2 (2% NM and 20% n-butanol v/v in diesel) will be a potential fuel for existing diesel engine.

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Renewable energy and sustainable development are the key technologies to offer solutions to the ever-increasing environmental pollutions and depleting conventional fuel reserves. With an aim to discuss the state of art technologies pertaining to the renewable energy domain, RTU (ATU) TEQIP III Sponsored 3rd International Conference on New and Renewable Energy Resources for Sustainable Future (ICONRER-2021) was organized by the Department of Mechanical Engineering, Swami Keshvanand Institute of Technology, Management and Gramothan, Jaipur in collaboration with Rajasthan Technical University and Department of Mechanical Engineering, Assiut University, Assiut (Egypt) from February 11 to 13, 2021. ICONRER is a series of the conference started in 2017 and it was 3rd event of that series.

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