IARJSET
ISSN (O) 2393-8021, ISSN (P) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Impact Factor 7.105 ⵋ Vol. 9, Issue 3, March 2022
DOI: 10.17148/IARJSET.2022.9333

EXPERIMENTAL INVESTIGATIONS ON CARDANOL AS FUEL ADDITIVE IN BIODIESEL FUELLED CI ENGINE

Sunil S[1], Shrishail Kakkeri[2], Srinivasa Rao K[3], Manjunatha N K[4]

[1]Assosiate Professor, Mechanical Engineering Department, Sri Venkateshwara College of Engineering, Bengaluru, Affiliated to Visvesvaraya Technological University, Belagavi, Karnataka, India

[2]Professor, Mechanical Engineering Department, Sri Venkateshwara College of Engineering, Bengaluru, Affiliated to Visvesvaraya Technological University, Belagavi, Karnataka, India

[3]Professor, Department of Basic Science and Humanities, Sri Venkateshwara College of Engineering, Bengaluru, Affiliated to Visvesvaraya Technological University, Belagavi, Karnataka, India

[4]Assistant Professor, Department of Basic Science and Humanities, Sri Venkateshwara College of Engineering, Bengaluru, Affiliated to Visvesvaraya Technological University, Belagavi, Karnataka, India

Abstract: Many countries that import crude oil are concerned about the fast expanding consumption of fossil fuel products in prime movers because it results in large foreign outflows. Increased exhaust emissions and the scarcity of these fuels are a major source of concern for everyone. As a result, it is vital to develop renewables that meet today's needs. Because they are renewable, vegetable oils have the potential to alleviate this problem. Biodiesel, which is made from non-edible oils, is a highly promising fuel for diesel engines. Biodiesel has a number of benefits, including the technical feasibility of mixing it with diesel, lower emissions, and the ability to utilise existing storage facilities. Combustion of fuels in engines is a crucial activity in the power generation and transportation industries. It is critical to develop better strategies for efficient combustion of current fuels, as well as methodology for burning various types of fuels in engines. With the inclusion of combustible nanoparticles, the efficiency of a CI engine using biodiesel can be improved. It is based on the finding that biofuels contain more oxygen than is necessary; the addition of fuel additives can aid in the entire usage of oxygen, result in the complete burning and the release of additional energy, increasing efficiency and lowering emissions. In the current research biodiesel is produced from dairy scum. Study of impact of bio based material (Cardanol) fuel additive on B20 dairy scum biodiesel blend is carried out using a 4 stroke, single cylinder diesel engine.

Keywords: Dairy Scum Biodiesel, Cardanol, Fuel Additives, Brake Thermal Effeciency.

1. INTRODUCTION

The consumption of petroleum fuels is increasing every day due to increase in population and standard of living. There is a need for search of alternatives as petroleum based fuels are depleting at a faster rate. Biodiesel produced from various sources is one of the key alternate to conventional diesel. “Biodiesel is described as fatty acid methyl or ethyl esters from vegetable oils or animal fats. It is renewable in nature, biodegradable and oxygenated” [1]. Biodiesel has crucial advantages as compared to conventional diesel fuels [2].Biodiesel has an advantage of reduced emissions and increased efficiency. Biodiesel produced from nonedible oils like Jathropa, Simarouba, Pongamia, rubber seed is becoming popular these days. Biodiesel can be mixed with petroleum diesel in various amounts and utilised in a standard engine without any modification. The viscosity of biodiesel mixes with petroleum diesel is dramatically reduced, and the engine's fuel management system can handle biodiesel blends without any issues [4]. Mixing additives to a fuel can improve its performance qualities. There is currently a surge of attention in using additives to improve the quality of the fuel [3]. Additives enhance radiative mass transfer, minimise ignition latency, and raise ignition temperature, all of which contribute to complete combustion [3]. Oxygenated additives, lubricity improvers, cetane improvers, and antioxidants additive are the different types of fuel additives [5]. Oxygenated additives are essential additions for diesel engines. Additional oxygen aids in the complete combustion of the fuel while reducing hazardous pollutants such as NOx. Properties of fuel will be affected directly by oxygenated additions [6]. The literature review shows that limited research

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has been carried out using cardanol as fuel additive. In the current research biodiesel is produced from dairy scum. Study of impact of bio based material (Cardanol) fuel additive on B20 dairy scum biodiesel blend is carried out.

Table 1: Nomenclature

BTE : Brake thermal efficiency	EGT: Exhaust Gas Temperature
B20: 80% Diesel + 20% biodiesel	CO: Carbon Monoxide
B20 C2.5: B20 + 2.5% Cardanol	HC: Hydrocarbon Emissions
B20 C5: B20 + 5% Cardanol	NOx: Oxides of Nitrogen
BSFC: Brake Specific fuel consumption	

2. MATERILAS AND METHODS

PREPARATION OF OIL

Dairy trash is collected from the effluent treatment plant's dairy waste expelling zone at KMF Dairy, Tumakuru, Karnataka. It is collected fresh and treated swiftly to keep away from the increase in free fatty acids caused by organic activity. Dairy waste is a turbid white substance with a semi-solid surface. The moisture content of collected waste is removed by warming it. Oil's FFA was found to be 4.13 percent.

PREPARATION OF BIODIESEL

The processed oil is subjected to twostep process. The first step is Esterification and the second is Transesterification.

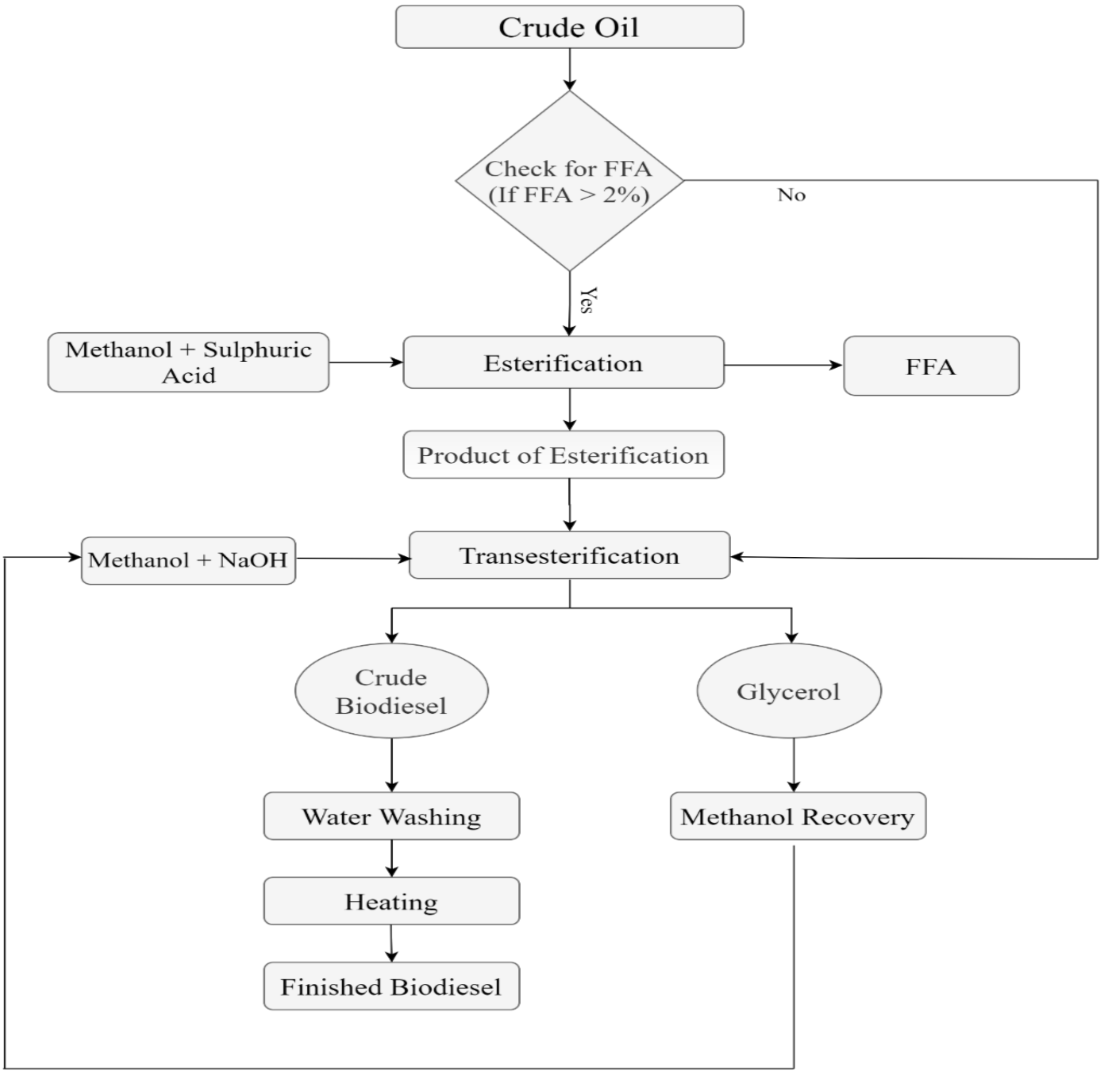

Fig1: Biodiesel Production Process

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Esterification reduces the FFA content of the oil in the presence of strong H_2SO_4 as an accelerator and methyl alcohol as a reactant. For 1000ml of oil, a 1:6 molar ratio of methyl alcohol and 2% v/v of H_2SO_4 based on FFA is used. This mixture is warmed for 2 hours at 65°C with continuous agitation, then allowed to settle overnight in an isolating jar. Due to its low density, the FFA material rises to the surface and is ejected from the oil, leaving the remaining oil for the following stage.

In the Transesterification process, for 1000 ml of oil, 100 ml of methyl alcohol and 1 percent w/v of KoH are added and the mixture is heated to 60°C with constant agitation for 2 hours. This reacting mixture is allowed to set by gravity. The lower layer, which contains glycerol and other impurities is separated from the mixture. The upper surface, containing the needed biodiesel is washed many times with moderate warm water and dried to remove any moisture.

PRODUCTION OF CARDANOL

Cashew Nut Shell Liquid (CNSL), a product acquired from the cashew shell, is a dark highly viscous liquid, with an unacceptable odour, rich in non-isoprenoid phenolic lipids. The CNSL is primarily composed of two compounds, cardol and cardanol. The structure of CNSL, cardol and cardanol is shown in fig 2. [7]

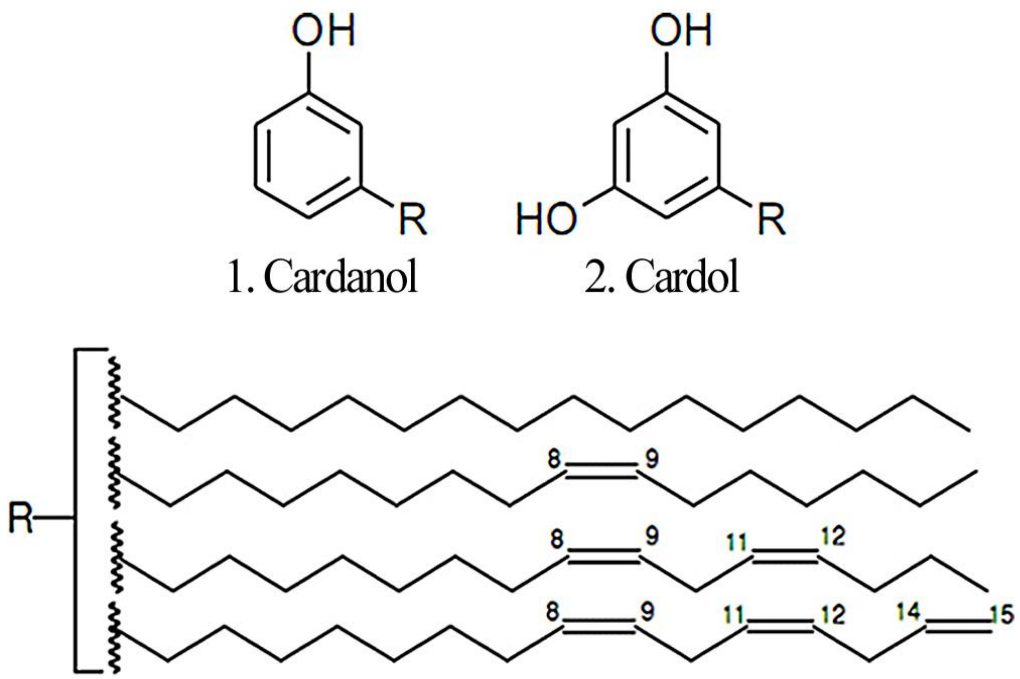

Figure 2: Main constituents of CNSL [7]

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Cardanol is obtained CNSL by fractional distillation. Cardanol is a monohydroxyl phenol having hydrocarbon chain in the meta position. Cardanol is the major constituent of CNSL. It is estimated in the literature that the composition of Cardanol is up to 65% (w/w) in CNSL. Cardanol has excellent antioxidant properties. Cardanol is popularly used as antioxidant and anticorrosive agent in lubricating oils.

BLENDING

Produced biodiesel is blended with petro-diesel in 20% proportions (B20). For preparation of 1 liter B20 blend 200ml of biodiesel & 800ml of petro-diesel is mixed thoroughly using magnetic stirrer for 20 minutes. The produced cardanol is mixed with B20 blend in 2.5% and 5% proportion (B20 C 2.5, B20 C 5).

PERFORMANCE/EMISSION TESTING

In this investigation, a single cylinder 4S water cooled diesel engine was used. . Five gas analyzer is used to measure emissions such as CO, HC, NOx, and CO_2 (Make: AVL Model: DIGAS 444 Analyser).

3. RESULTS AND DISCUSSIONS

PERFORMANCE ANALYSIS

Fig 3 demonstrates the variation of BTE with respect to load for various samples. The BTE achieved at full load are 30.17 and 31.21 for Diesel and B20 respectively. In case of cardanol blended fuel samples the BTE achieved at full load is

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32.35 and 31.75% for B20 C 2.5% and B20 C 5% blends respectively. There is an increase of 1.14% and 0.54% efficiency of B20 C 2.5 and B20 C5 in compared with that of B20. The explanation for the improved efficiency could be due to cardanol's antioxidant properties, which cause complete burning and the release of excess energy in turn increasing the efficiency [8]. With increase in concentration of cardanol the BTE decreases. The reduced BTE may be attributed to the high viscosity which leads to poor atomization and low calorific values of the blends.

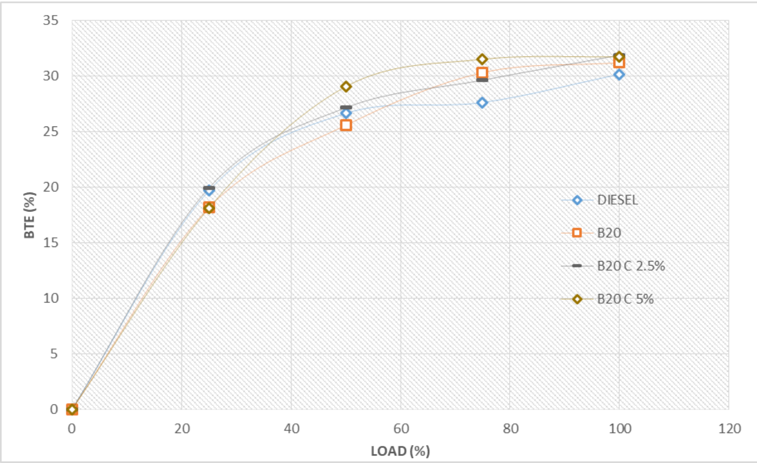

Fig 3: BTE

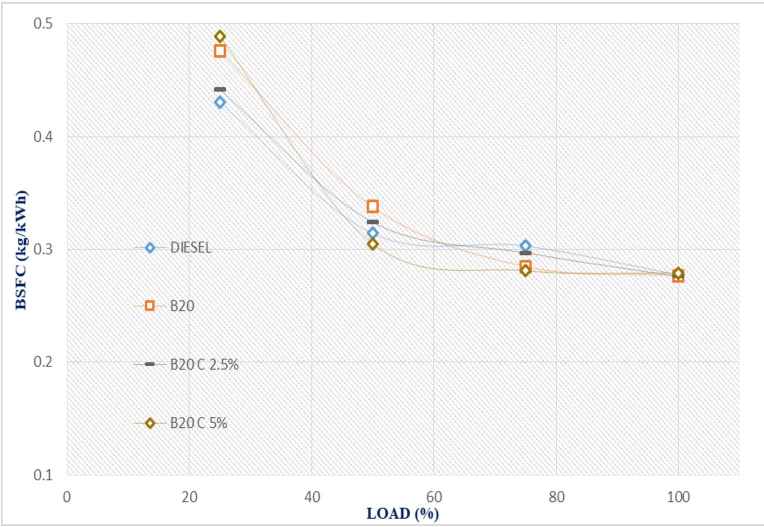

Figure 4 demonstrates the variation of BSFC with respect to load. BSFC denotes the quantity of fuel consumed to produce a unit power. The BSFC of all the samples decreased with increment in load. At maximum load condition the BSFC was 0.2774 and 0.2765 kg/kWh for diesel and B20 respectively. In case of cardanol blended fuel samples the BSFC at full load was found to be 0.2760 and 0.2790 for B20 C 2.5% and B20 C 5% blends respectively. The BSFC of B20 C 2.5% was lesser than that of B20 whereas in case of B20 C 5% it was found to be higher. In aggregate, it can be stated that adding cardanol to the fuel expedited the process of burning and reduced fuel usage [9].

Figure 5 shows the variation of EGT with respect to load. It is noted that EGT of all the test fuels increased with load. The EGT in case of diesel and B20 and diesel at full load is found to be 385. 6 ^{0}C and 395.26 ^{0}C respectively. The higher EGT of B20 blend is an indicator of complete combustion. In case of cardanol blended fuel samples the EGT at full load was found to be 393.7 ^{0}C and 381 ^{0}C for B20 C 2.5% and B20 C 5% blends respectively.

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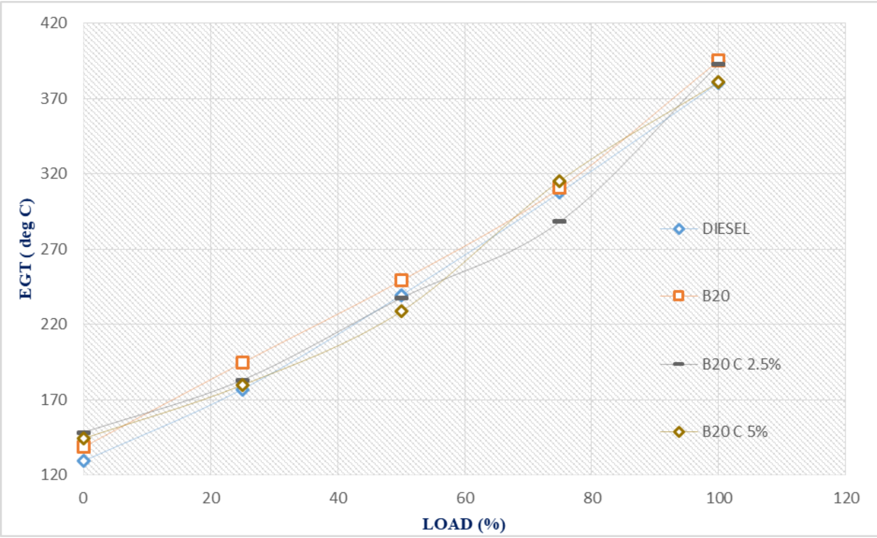

Figure 5: EGT

Emission Analysis

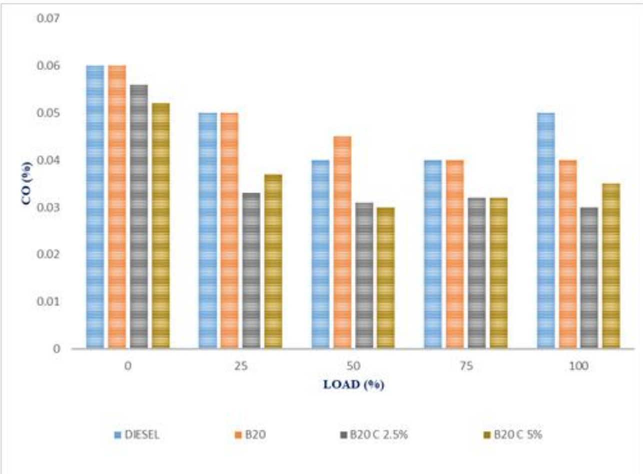

Figure 6: CO

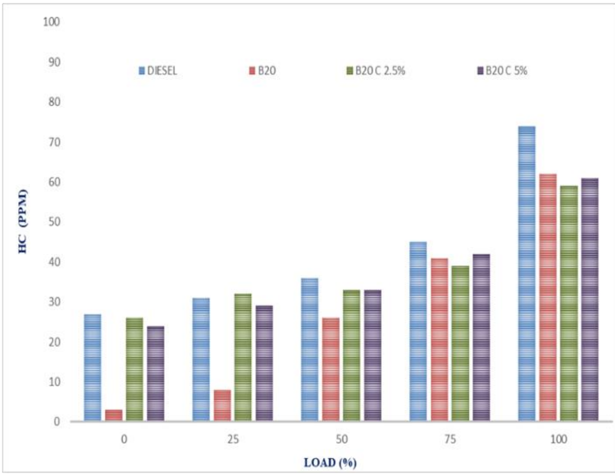

Figure 7: HC

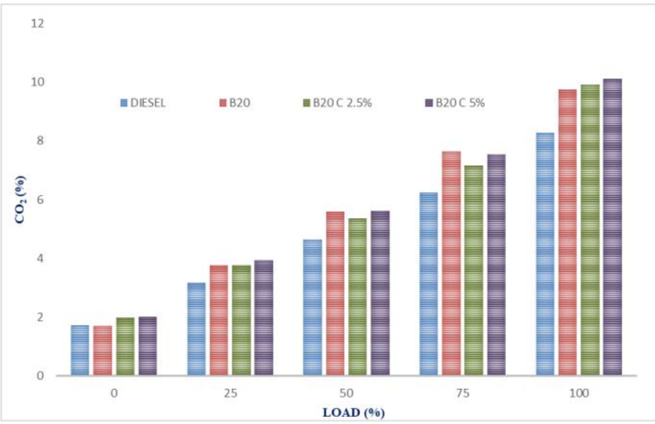

Figure 8: CO_2

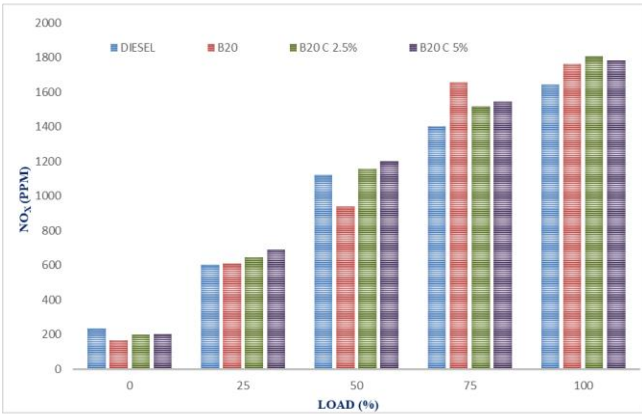

Figure 9: NOx

Figure 6 demonstrates the CO emission for various blends and diesel. When comparing B20 to diesel at full load, CO emissions are determined to be 20% lower. In case of cardanol blends CO emission is reduced by 20% and 12.5% for B20 C 2.5% and B20 C 5% blends respectively. This could be because cardanol releases more oxygen during burning, result in the complete burning [11] [12].

Figure 8 demonstrates the variation of CO_2 emission. When comparing B20 to diesel, CO2 emissions are determined to be 29.07 percent greater. The CO_2 emissions increased by 6.54 %and 1.8% for B20 C 2.5% and B20 C 5% blends respectively at full load.

Figure 9 demonstrates the variation of NOx emission. When comparing B20 to diesel at full load, NOx emissions are determined to be 17.68% greater for B20. In case of cardanol blends NOx emission is increased by 2.65 and 1.14 % for B20 C 2.5% and B20 C 5% blends respectively. This may be attributed to the rapid combustion process which in turn increases the combustion temperature promoting NOx formation [10].

Figure 7 demonstrates the variation of HC emission for various samples and diesel. When comparing B20 to diesel, the HC outflow is determined to be 6.17 percent lower. In case of cardanol blends HC emission is decreased by 14.41 and 9.21 % for B20 C 2.5% and B20 C 5% blends respectively. This reduction may be attributed the extra oxygen content of cardanol leading to better combustion.

4. CONCLUSIONS

In the current research biodiesel is produced from dairy scum. Study of impact of bio based material (Cardanol) fuel additive on B20 dairy scum biodiesel blend is carried out. The fuel additives are mixed in B20 dairy scum biodiesel blend and tested in a 4 stroke, single cylinder diesel engine.

- There is an increase of 1.14% and 0.54% efficiency of B20 C2.5 and B20 C5 as compared to that of B20 blend.
- The BSFC at full load was found to be 0.2760 and 0.2790 for B20 C 2.5%, B20 C 5% blends respectively. The BSFC of B20 C 2.5% was lesser than that of B20 whereas in case of B20 C 5% it was found to be higher.
- In case of cardanol blended fuel samples the EGT at full load was found to be 393.7 ^{0}C and 381 ^{0}C for B20 C 2.5%, B20 C 5% blends respectively.
- CO emission is reduced by 20% and 12.5% for B20 C 2.5%, B20 C 5% blends respectively in comparison with B20 biodiesel blend.
- The CO_2 emissions increased by 6.54 %and 1.8% for B20 C 2.5% and B20 C 5% blends respectively at full load in comparison with B20 biodiesel blend.
- NOx emission is increased by 2.65 and 1.14 % for B20 C 2.5% and B20 C 5% blends respectively in comparison with B20 biodiesel blend.
- HC emission is decreased by 14.41 and 9.21 % for B20 C 2.5% and B20 C 5% blends respectively in comparison with B20 biodiesel blend.
- Organic fuel additive derived from cashewnut shell liquid showed competitive performance and emission results.

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