



Investigation on EGT, PM and NOx Emissions from a Diesel Engine Fueled With Azadirachta Indica Biodiesel-Diesel Blends

Sirivella Vijaya Bhaskar

Department of Mechanical Engineering, Sreenidhi Institute of Science & Technology
Ghatkesar, Hyderabad-501301, TS, India

Abstract: Over the many decades, the search for sustainable energy sources is getting basic and basic for many nations over the globe keeping in mind to achieve the goal of meeting the present and future vitality request and additionally to lessen the air pollution. The past research results raised concern about price-raise of food products when edible oils as feedstock for biodiesel. Recently the non-edible oils are promising as the prospective alternative to edible oils for biodiesel production as alternative renewable fuel source. The objective of the present paper is to investigate the exhaust gas temperature (EGT), and the exhaust emissions (PM and NOx) from a direct injection (DI) diesel engine fuelled with azadirachta indica oil methyl ester (AIOME). The experimental results of single cylinder, 4-stroke, water cooled, compressive injection direct injection engine fuelled with azadirachta indica biodiesel and different blends (B20A, B40A, B60A and B100A) of AIOME were revealed that neat AIOME bio-diesel has higher exhaust gas temperature, lower particulate matter, and relatively higher NOx emission when compared with petro-diesel fuel.

Keywords: Azadirachta Indica Oil; Biodiesel; Methyl Ester; Emission Characteristics; Vegetable oils; Transesterification

I. Introduction

Ever expanding worldwide utilization of energy for various purposes, numerous nations have focused on exploration for alternative energy sources to meet their present and future demand. The economy of many developing nations has become slow, because of huge spending caused by oil imports and steep rise in petroleum prices. Preparation of plant-based biodiesels, domestically using vegetable oils, not just enhances the rural economy and curbs the ecological contamination. Currently, edible oils are most commonly used in the production of biodiesels and have a remarkable contribution in the preparation of alternative fuels. Edible oils like palm, coconut, soybean, peanut, sunflower, rapeseed etc., are used as main feed-stocks in biodiesel production. The usage of edible oils in the production of biodiesel has raised the concerned of praise increase in food and its related products. In the recent years, due to less production of vegetable oils, the researchers have started to used non-edible oils such as jatropha curcas, madhuca indica, pongamia, neem oils etc., has feedstock of the biodiesels [1-6]. Moreover, the non-edible oils plants can grow in uncultivated, unfertile barren lands with little/no water supply.

I.TNazzalet al. were conducted an experimental analysis using diesel blends of sunflower oil in a TD111 model, single cylinder, air-cooled diesel engine with three mixtures of sunflower oil/diesel ratios of 5:95, 8:92 and 11:89 in addition to diesel fuel and revealed that the brake power, brake thermal efficiency and exhaust gas temperature were lower than the diesel fuel while brake specific fuel consumption was increased [7]. Huzayin et al. have done experimental investigation on emission and performance characteristics using Blends of jojoba oil with gas oil and their experimental results shown that slightly reduced engine power, insignificant increase in brake specific fuel consumption (BSFC), reduction in NOx and soot emission using blends of jojoba oil with gas oil as compared to gas oil [8]. B.S Chauhan et al. evaluate the performance and emission characteristics of Kirloskar diesel engine using unheated and preheated Jatropha oil. Their experimental evaluation shown that the engine has lower brake thermal efficiency (BTE) and higher brake specific energy consumption (BSFC) with unheated Jatropha oil when compared with diesel fuel. But with preheated Jatropha oil, these parameters were superior to unheated Jatropha oil. The exhaust emissions (CO, HC and smoke opacity) were lower from the engine than diesel fuel for both conditions [9]. Hüseyin Aydin et al. have conducted experimental studies to evaluate the performance and emission characteristics of CI engine using cotton seed methyl ester (CSOME) and its diesel blends of B5, B20, B50, B75, and B100. They have identified slight increase in engine torque for lower blends with reduced exhaust emissions. The lower blends of CSOME can partly be replaced for petro-diesel fuel unmodified engine [10]. Gopinath et al., have carried-out experiments using corn oil Methyl Ester (COME) and its blends with diesel in a single cylinder direct injection diesel engine and noticed less CO₂, NOx and unburned hydrocarbon (UBHC) emissions with all

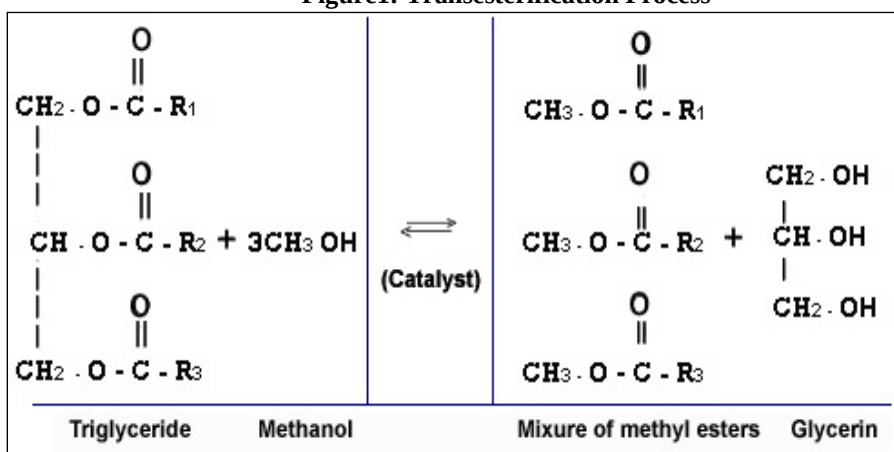
tested blends of biodiesel when compared with petro-diesel [11]. Rakopoulos et al. have carried-out an extended experimental analysis and compared the use of various vegetable oils such as soybean oil, rapeseed oil, cotton seed oil, sunflower oil, palm oil, corn oil and olive kernel oil and their corresponding methyl esters at blend ratios of 10/90 and 20/80, in a standard, 4-stroke, direct injection diesel engine. The tests were conducted at two different engine speeds and three different loads and revealed that the vegetable oil blends show reduction of emitted smoke combined with slight increase in NO_x with no influence on the thermal efficiency [12].

II. Materials and Methods

A. Preparation of Biodiesel

The azadirachta indica oil was collected from local vendor, filtered and kept some time to settle-down the impurities present. Then the biodiesel was prepared by using transesterification method to improve the combustible and other physic-chemical properties. Because, the neat azadirachta indica oil has higher viscosity and higher density than diesel that causes operational problems in engine. The figure 1 below shows the transesterification reaction used in production of biodiesel which is called methyl ester of azadirachta indica oil (AIOME). In this process, the carbonyl carbon of the starting ester carry out nucleophilic attack by the arriving alkoxide to give a tetrahedral intermediate, which either reverts to the starting material or proceeds to the transesterified product. The chemical reaction between the fat or oil and the alcohol takes place and forms methyl esters and heavy glycerin which will be separated later to prepare biodiesel. This neat AIOME biodiesel was then filtered and further purified prior to use in diesel engine as fuel in the place of petro-diesel fuel.

Figure1: Transesterification Process



B. Fuel Properties

In the present research study, azadirachta indica oil methyl ester was blended with diesel fuel and prepared 20:80 (BA 20), 40:60 (BA40), 60:40 (BA60) and 100:0 (BA100) blends on volume basis. The chemical properties of diesel fuel and azadirachta indica oil methyl ester (AIOME) were evaluated and are presented in Table I.

Table I: Chemical Properties of Tested Fuel

Property	Diesel	AIOME
Kinematic Viscosity at 40 ^o C (Cst)	3.58	4.48
Density at 15 ^o C (Kg/m ³)	830	867
Flash Point (°C)	51	176
Cetane Number	50	52
Calorific Value (KJ/kg)	42000	41300
Total Sulphur (% by mass)	0.01	Nil

III. Experimental Setup

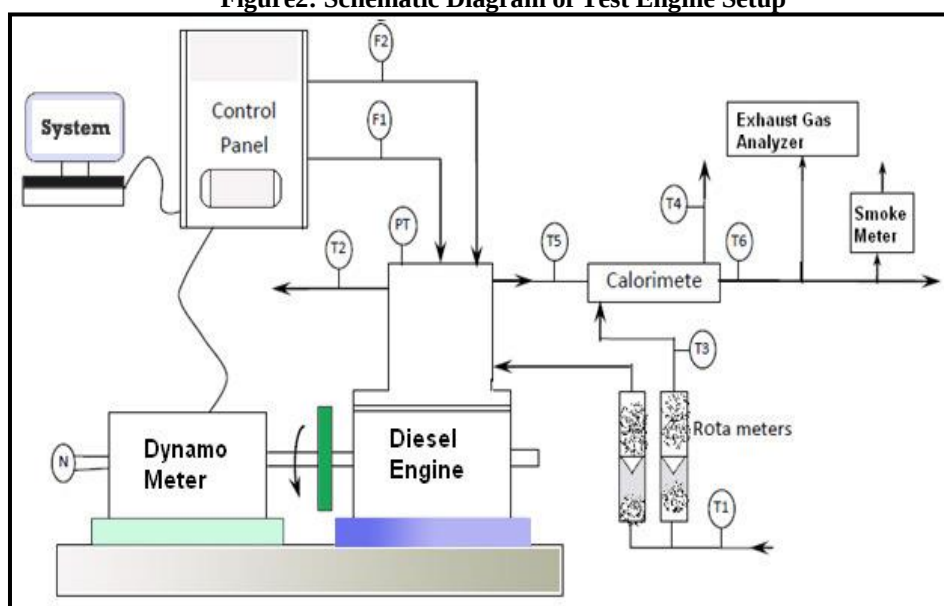
The experimental evaluation was carried-out using a single cylinder, water-cooled, 4-stroke, direct injection (DI) diesel engine when fueled with diesel and blends of AIOME biodiesel with different ratios. The engine is coupled with an eddy-current dynamometer. The dynamometer was used for loading the engine at pre-defined load conditions such as quarter, half, 3/4 and full load. Before conducting the experiments, the engine was started with

diesel and kept running until warmed-up which takes few minutes and then readings were taken for analysis. Then it was continued with methyl esters of azadirachta indica oil and its diesel blends. The detailed specifications of the test engine are presented in Table II. The test setup is presented in Figure 2 as a schematic diagram.

Table II: Specifications of Test Engine

Engine Make	Kirloskar AV1, India
Engine Details	Single Cylinder, Four stroke, Water cooled
Injection Type	Direct Injection
Bore & Stroke	80 × 110 mm
Rated Power	3.7 KW (5 HP) at 1500 rpm
Speed	1500 rpm
Injection Pressure	200 bar
Compression Ratio	16.5:1
Dynamometer	Eddy Current

Figure2: Schematic Diagram of Test Engine Setup



T1	Inlet water temperature	PT	Pressure transducer
T2	Outlet engine jacket water temp	F1	Air intake differential pressure unit
T3	Inlet water temperature	F2	Fuel Flow differential pressure unit
T4	Outlet cal. water temperature	T6	Exhaust gas temperature after Cal
T5	Exhaust gas temperature before Cal		

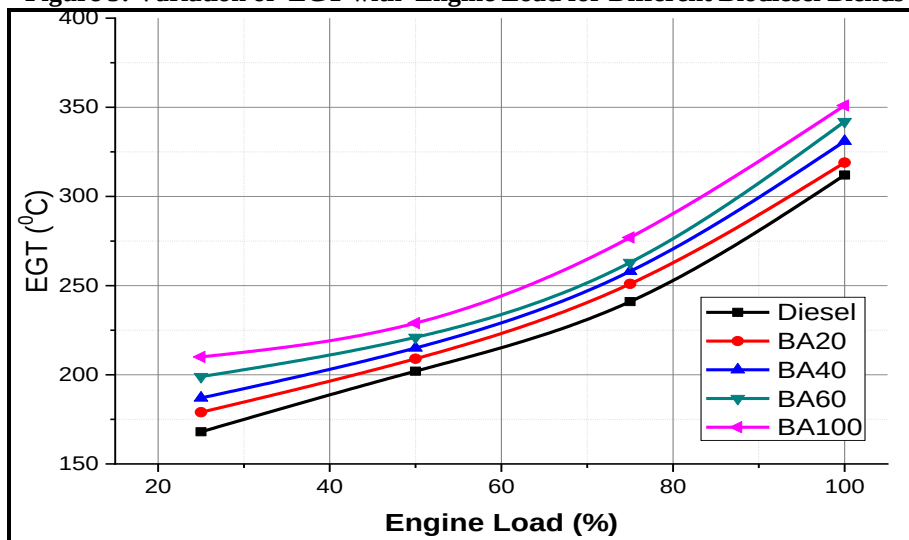
IV. Results and Discussion

The effect of azadirachta indica oil methyl ester (AIOME) and its diesel blends on engine emission characteristics of single cylinder, DI diesel engine was evaluated in terms of particulate matter (PM) and NO_x emission and exhaust gas temperature (EGT). The conclusions drawn from the test results were presented in below paragraphs.

A. Exhaust Gas Temperature (EGT)

The variation of EGT of a test diesel engine with engine load for diesel and azadirachta indica oil methyl ester (AIOME) blends was illustrated in Figure 3. The graph reflects that 20% (BA20) of AIOME has lower exhaust gas temperature (EGT) values among all blends of tested biodiesel, but little higher than diesel fuel. The highest EGT by neat azadirachta indica biodiesel. The EGT was increased with the increase of percentage of AIOME in biodiesel blend and increased with reference to increase in engine load. It was also noticed that EGT from all blends of AIOME biodiesel is higher than the diesel.

Figure 3: Variation of EGT with Engine Load for Different Biodiesel Blends



B. Particulate Matter (PM)

The variation of particulate matter (PM) with engine load of the test diesel engine when AIOME biodiesel and its diesel blends used as fuel was shown in Figure 4. The emissions of particulate matter are lowest value with AIOME biodiesel and its diesel blends when compared with diesel. The experimental test results show that the PM emissions are lower with BA100% as compared to diesel fuel and it is decreasing with the increase of AIOME percentage in the biodiesel blend. It was noticed that BA20 blend of AIOME has highest particulate matter emission and BA100 has lowest among all the tested biodiesel blends.

C. NO_x Emission

Figure 5 presents the variation of oxides of nitrogen emission (NO_x) with engine load for different blends of AIOME biodiesel and diesel fuel. The test results show that NO_x emission increased with the increase in the engine load for all tested fuels at rated injection pressure. It was noticed that an increase of oxides of nitrogen with increase in percentage of AIOME biodiesel in blend. At part load conditions the variation of NO_x emission of biodiesel and diesel has slight difference, but at higher load conditions NO_x emission of AIOME are significantly distinct and BA100 blend of biodiesel has higher NO_x values than diesel fuel and their other blends. The NO_x emission for every 20% addition of AIOME blend in the biodiesel was affected and decreased gradually with the increase of AIOME percentage in the biodiesel blend. The BA100 blend has the lowest NO_x among all the tested blends of AIOME biodiesel and diesel fuel and BA20 has the highest in among biodiesel blends and after diesel fuel.

Figure 4: Variation of PM with Engine Load for Different Biodiesel Blends

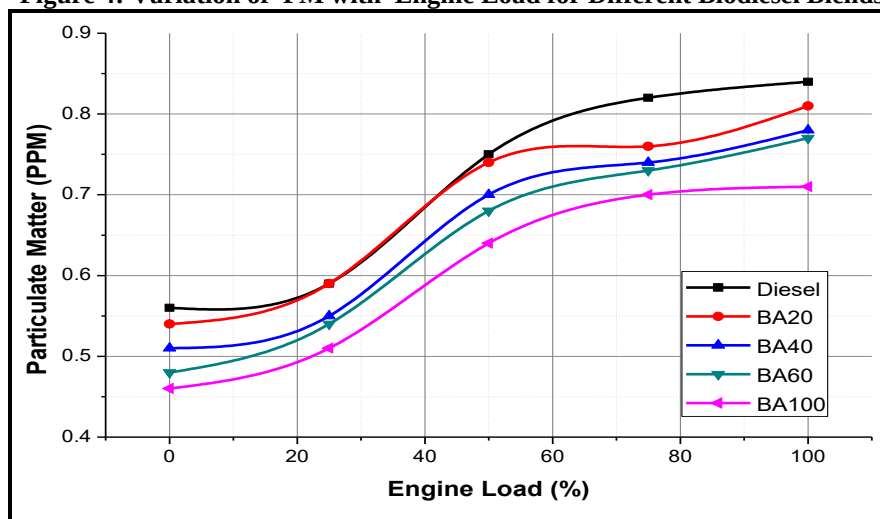
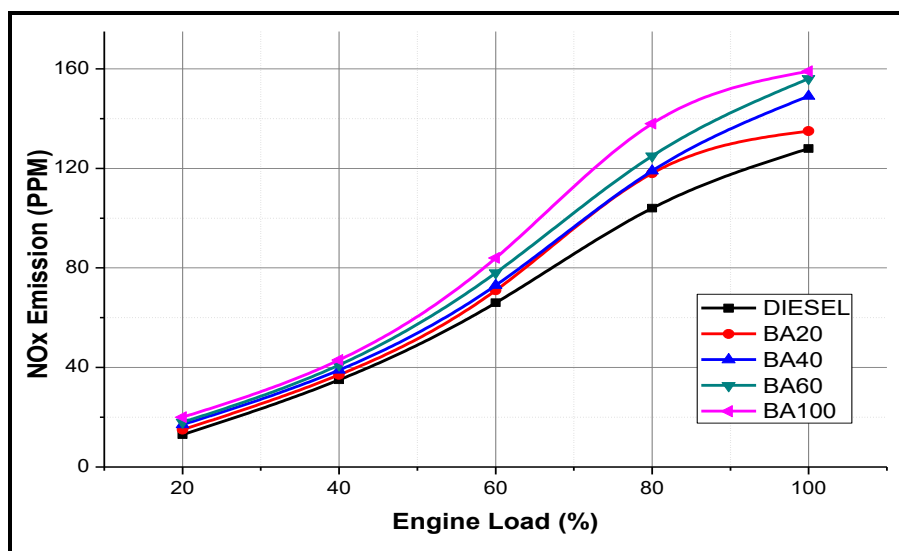


Figure 5: Variation of NO_x with Engine Load for Different Biodiesel Blends



V. Conclusions

The experimental results conducted on a single cylinder, four stroke, water cooled diesel engine fuelled with different blends (BA20, BA40, BA60 and BA100) of azadirachta indica oil methyl ester (AIOME) at different engine load condition revealed that the lowest EGT and NOx emissions noticed with diesel, followed by BA20 blend of AIOME. The neat biodiesel has released lowest particulate matter among all the tested fuels at rated speed of 1500 rpm. All emission characteristics were increased with the increase of load. The test results corroborated that biodiesel prepared from azadirachta indica oil can be used in unmodified diesel engine. It was also observed that when proportion of azadirachta indica oil methyl ester (AIOME) in the biodiesel increased, EGT and NOx were increased and PM was decreased.

VI. References

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