International Journal of Advanced Educational Research
ISSN: 2455-6157
Impact Factor: RJIF 5.12
www.educationjournal.org
Volume 3; Issue 1; January 2018; Page No. 484-485

Evaluation on nitrogen oxide (NOx) emission of compression ignition engine using nano-particles as constituent of biodiesel

Amit
Assistant Professor, Mechanical Engineering, U.I.E.T, M.D.U, Rohtak, Haryana, India

Abstract
The main objective of this research work is to evaluate the Nitrogen oxide (NOx) Emission of compression ignition engine using nano-particles as constituent of jatropha biodiesel and diesel. In order to evaluate the effect of nano-paritcles such as cobalt oxide and iron oxide fuelled with diesel and jatropha biodiesel, an experimental investigation was carried out to study the emission characteristics of single cylinder, four stroke, water cooled compression ignition engine. Cobalt and Iron oxide nano-particles were added with jatropha biodiesel and diesel in different mixed proportions. The range of nano-particles size was 30-100 nanometers. The result showed reduction in Nitrogen oxide (NOx) Emission.

Keywords: nano-particles, biodiesel, nitrogen oxide (NOx) emission, compression ignition engine

Introduction
Biodiesel is considered as the main alternative fuels for compression ignition engines, because of their properties such as rich oxygen content, higher kinematic viscosity, reduced smoke emission and diluted level of pollutants from the engine exhaust (Carbon monoxide, particulate matter and unburned hydrocarbons). Biodiesel containing 10 % oxygen content helps in better combustion of the fuel; on the other hand, it results in the formation of high local temperatures inducing more NOx, HC and COx emissions during combustion. Due to such limitations, the usage of biodiesel in engines is not familiar and commercialized. So, to control such NO emissions many strategies have been followed by researchers around the countries such as biodiesel blends, engine modification, exhaust gas reduction techniques and alteration in fuel formulations. From the literatures, the blending of two nano particles in biodiesel shows the most promising results for the performance characteristics of the engine. So, in this present experimental investigation, two nano particles are blended in various parts per million (ppm) with Jatropha biodiesel and the performance characteristics of the test fuels are investigated in comparison with neat diesel and neat biodiesel as base fuels.

Experimental Setup
The experimental investigations were carried out in two phases. In the first phase, the various properties of modified biodiesel was determined and compared with those of the base fuels. The properties studied were the flash and fire points and viscosity. In the second phase, performance tests was conducted on a single cylinder compression ignition water cooled engine using the modified and base fuels, in order to evaluate the engine performance. Jatropha Biodiesel was prepared by trans esterification process with ethanol by using NaOH as catalyst. Cobalt and Iron oxide nano particles were prepared in Nano-Technology Laboratory. The morphology of the alumina and cerium oxide nanoparticles were determined by Scanning Electron Microscope and the crystalline phase of nanoparticles were determined by X-ray Diffraction. Different types of test fuels were prepared by equally dispersing Iron Oxide (Fe_2O_3) and Cobalt Oxide (Co_3O_4) nano particles in mass fraction forming 10 to 100 parts per million (ppm) with Jatropha biodiesel and diesel. The Exhaust gases were measured by exhaust gas emission analyzer.

Preparation of Fuels
Six types of test fuels are prepared by equally dispersing Iron Oxide (Fe_2O_3) and Cobalt Oxide (Co_3O_4) nano particles in mass fraction forming 10,20,30,40,50 and 60 ppm with Jatropha biodiesel. To prepare the JBD10F10C test fuel, nano particles Fe_2O_3 and Co_3O_4 of 10 ppm each, are added to the Jatropha biodiesel and dispersed using an apparatus called Ultrasonicator. An Ultrasonicator is used for equally dispersing Fe_2O_3 and Co_3O_4 nano particles in Jatropha biodiesel for nearly 1–1.5 hours before the start of the experiment. The stability characteristic tests are carried out for the test fuels in graduated test tubes and found stable for 3 days.
JBD20F20C, JBD30F30C, JBD40F40C, JBD50F50C, JBD60F60C are prepared by same process. JBD10F10C is 10 ppm iron oxide nanoparticle and 10 ppm cobalt oxide nano particle in blend of jatropha biodiesel. JBD20F20C is 20 ppm iron oxide nanoparticle and 20 ppm cobalt oxide nano particle in blend of jatropha biodiesel. JBD30F30C is 30 ppm iron oxide nanoparticle and 30 ppm cobalt oxide nano particle in blend of jatropha biodiesel. JBD40F40C is 40 ppm iron oxide nanoparticle and 40 ppm cobalt oxide nano particle in blend of jatropha biodiesel. JBD50F50C is 50 ppm iron oxide nanoparticle and 50 ppm cobalt oxide nano particle in blend of jatropha biodiesel. JBD60F60C is 60 ppm iron oxide nanoparticle and 60 ppm cobalt oxide nano particle in blend of jatropha biodiesel.

Determination of Fuel Properties
The viscosity, flash and fire points were measured using standard test methods**.** The viscosity was measured by using the Redwood viscometer. A flash and fire point apparatus was used for measuring the flash point and fire points.

Description of the Test Engine
A four stroke, single cylinder, water-cooled compression ignition engine was used to conduct the performance. Engine was running at a constant speed of 1500 rpm with a rated power of 4.4 kW. Before and after the engine being run on the test fuel, the engine is allowed to run on neat diesel in order to ensure the consumption of test fuels in the fuel injection system is fully purged. Standard constant speed load tests were also performed on the engine. An electrical dynamometer was used for loading the engine. Specifications of the engine used for the performance study are given in Table 1, and a schematic block diagram of the experimental test facility is illustrated in Figure 1.

Table 1

Manufacturer	P.S.G Coimbatore
Type	4Stroke,Single Cylinder
Ignition System	Compression Ignition
Stroke	110 mm
Bore	88 mm
Rated Power	5 HP
Rated Speed	1500 RPM
Swept Volume	558 c.c
Loading Device	Electrical Dynamometer

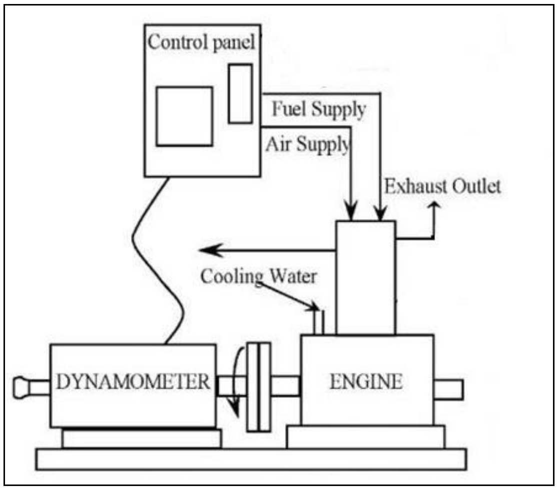

Figure 1

Result and Discussions
Emission characteristics were studied for each fuel blends. Nitrogen oxide (NOx) was calculated based on different load condition for each blend with exhaust gas emission analyzer. All the experiment was performed at constant engine speed of 1500 rpm.

Nitrogen oxide (NOx) Emission
The variation of Nitrogen oxide (NOx) Emissions engine with brake load for diesel and various blends were plotted on graph as shown in fig.2. The result showed that the addition of 40 parts per million cobalt oxide and iron oxide nano-particles in mixed proportion with 10% jatropha biodiesel and 90% diesel (JBD40F40C) at full load condition showed reduction in nitrogen gas emission. The result showed nitrogen oxide emission was reduced by 8%.

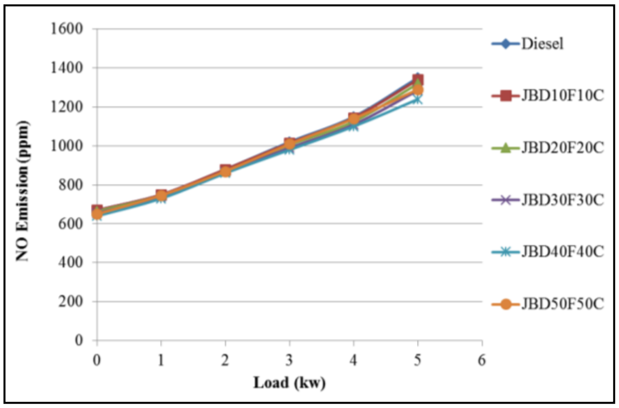

Fig 2: Load vs NO Emission

Conclusions
The addition of 40 parts per million cobalt oxide and iron oxide nano-particles in mixed proportion with 10% jatropha biodiesel and 90% diesel (JBD40F40C) at full load condition showed reduction in exhaust gas emission. Nitrogen oxide emission was reduced by 8%.

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