International Journal of Advanced Research and Development
ISSN: 2455-4030
Impact Factor: RJIF 5.24
www.advancedjournal.com
Volume 2; Issue 6; November 2017; Page No. 901-903

Improvement in brake thermal efficiency of direct compression ignition engine by adding nano-particles

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

Abstract
The main objective of this research work was to improve the brake thermal efficiency of direct compression ignition engine by adding nano particle in biodiesel. An Experimental analysis was carried to study the performance characteristics of four stroke, single cylinder, water cooled direct injection diesel engine. Nano particles were added with biodiesel in mixed proportion of 10,20,30,40,50,60 parts per million. The range of nano particle size was 35-80 nanometer. The engine was loaded with different brake power with each blend of fuel. The improvement in brake thermal efficiency is observed.

Keywords: nano-particle, biodiesel, brake thermal efficienccy

Introduction

Biodiesel is investigated as the main alternative fuel for compression ignition engines because of their properties such as heavy oxygen content and higher kinematic viscosity. Biodiesel containing 12 % oxygen helps in better combustion of the fuel. However the usage of biodiesel in engines is not familiar and commercialized. Many strategies have been followed by researchers around the countries such as biodiesel blends, engine modification and alteration in fuel formulations. Among them, fuel formulation techniques are considered as the most beneficial way of enhancing the engine performance substantially. Nano particle blended test fuels show better thermal properties because of advanced surface area to volume fraction of the nano particle. A small number of experiments were conducted with nano particles as additives in both diesel and biodiesel fuels with improved brake specific fuel consumption. An experimental investigation with cerium oxide nano particle as addition (at 20, 40 and 60 ppm (parts per million)) in Jatropha biodiesel fuel had shown significant improvement in brake specific fuel consumption. Other experimentations with cerium oxide nano particles as additives in diesel, castor biodiesel and ethanol blends had shown significant improvement in brake specific fuel consumption.

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, 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 bio diesel 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. The method for preparation of the fuels with the nanoparticles additive along with the experimental methods for obtaining the fuel properties and the performance test are all presented below.

Preparation of Fuels

Jatropha Biodiesel is prepared by transesterification process with ethanol by using NaOH as catalyst. Cobalt and Iron oxide nano particles are prepared in Nano-Technology Laboratory. The morphology of the cobalt and Iron oxide nanoparticles are determined by Scanning Electron Microscope and the crystalline phase of nanoparticles are determined by X-ray Diffraction. 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. The same procedure is carried out for preparation of fuel JBD20F20C, JBD30F30C, JBD40F40C, JBD50F50C, JBD60F60C respectively. Where 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

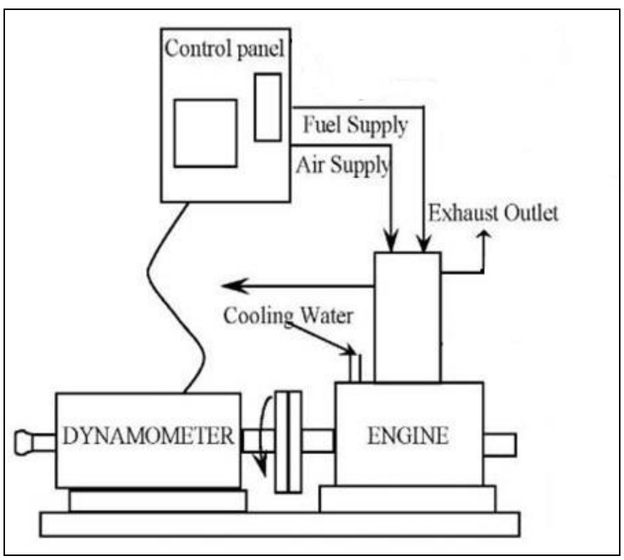

Fig 1

Result and Discussions

Engine Performance was studied for each fuel blends. Brake thermal efficiency calculated based on different load condition for each blend. All the experiments were performed at constant engine speed of 1500 rpm.

Brake Thermal Efficiency (BTE)

Fig.2 illustrates variations of brake thermal efficiency (BTE) with different Loads for different blends. The result shows improved brake thermal efficiency for blend of JBD40F40C (i.e. 32.5%) as compare to neat diesel (i.e. 32 %) at full load condition.

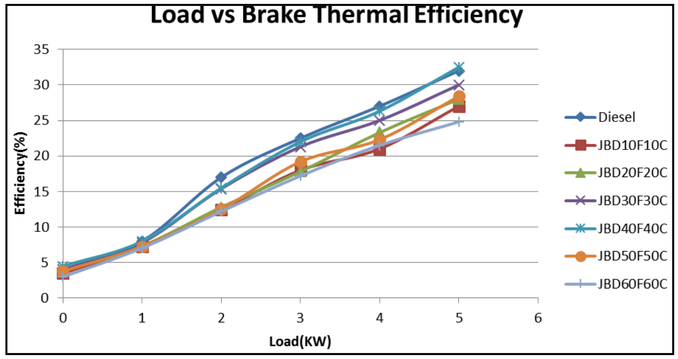

Fig 2

Conclusions

For JBD40F40C test fuel higher brake thermal efficiency (32.5%) is observed, which is greater than the brake thermal efficiency of neat diesel (32%).

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