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Experimental Investigation on Rhombus Grooved piston with Jatropha Biodiesel and Al_2O_3 Nano Fluid

[1]P. Jaya Prakash [2] Dr. S. Sunil Kumar Reddy [3]P.Kesavulu [4]A. Suresh
[1]PG Scholar [2] Professor & HOD, [3][4] Assistant Professor
[1][2][3]Dept. of Mechanical Engineering,
Siddhartha Institute of Engineering & Technology, Puttur, AP, India

Abstract: -- **The CI engines fuelled with diesel plays a very vital role in Industrialization and transportation sectors. However, the depletion of petroleum products isincreasing day to day. Due to high emissions from the petroleum products there is a strict regulations lay down by the government to the engine manufactures to save the environment from the pollution.Hence the researchers are in the processes of identifying a suitable alternate fuel i.e.biofuelssuch as Jatropha oil, Pongamia oil, Rice bane oil, Corn oil, Neem oil etc. Among all jatropha is considered to be the best replacement because these plants can grow in any environmental conditions and the properties are also nearer to diesel. With minor changes in the diesel engine, Jatropha biodiesel can be directly replaced with diesel. But one of the major drawbacks of Jatropha biodiesel are its flow characteristics and the viscosity of the fuel. In the present work to overcome this, nano additive (Aluminum oxide) is added to the biodiesel which enhances the properties of the fuel. The performance and emissions of diesel engine is experimentally investigatedwith biodiesel 20% by volume (B20) by using the nano additive 50 ppm, 100 ppm and 150 ppm. The performance of the engine depends on the formation of homogeneous mixture and turbulence inside the combustion chamber. Hence in the current work six number of Rhombus grooves are created on the piston crown to enhance turbulence in the chamber and results in the enhance of performance and reduction of the engine emissions. Among all blends the B20 biodiesel with 100 ppm nano additive showed better performance compare to diesel**

Key words: **--Aluminum oxide, Emissions Characteristics, Grooved piston, Jatropha Biodiesel, Nano additives, Normal piston, Performance.**

I. INTRODUCTION

Diesel engines have been used widely as a work transport for the industry from very earlier periods. Due to their high power, and high fuel economy their used at wide range of applications. Thedemand and consumption of dieselis increasing day by day with increase of utilization of diesel engines and development, which results higher pollution due to their emissions. So to decrease the consumption and emissions of diesel we are replacing the diesel with the alternative fuels(biodiesel). The alternative fuels are renewable and eco-friendly in nature. At present the world energy situation is heavily focusing on alternative fuels. Due to lower heating value of alternative fuels in present work we are adding metal oxide (Aluminum Oxide) Nano particles to bio fuel will improve the engine performance as well as reduce the exhaust emissions. Many researches had tried on Jatropha as a replacement for diesel and confirmed that with minor changes in engine, the efficiency of diesel engine can be improved marginally. But due to the higher viscosity of Jatropha and also the flow capacity of Jatropha is less which is the major drawback. To overcome this problem, in the present work it is planned to work with blending process. In the work it is planned to go with B20 (80% diesel + 20% Jatropha).It is also reported that due to high reactive nature of aluminum oxide while adding to Jatropha bio diesel could enhance the combustion properties of biodiesel due to the supply of oxygen in the combustion process. Size of Nano particles may also affect the parameters like combustion process,ignition delay and burning rates of fuel.

II. LITRATURE REVIEW

Considerable amount of research work has been done on various types of nano additives in diesel engines with biodiesels. Some of them are presented below. M. Mohan Rao et., [1] Investigated the effect of Zinc oxide as a fuel additive in various proportions on diesel engine performance fuelled with Palmolion Stearin Wax biodieseland concluded that the engine performance and emissions are better compare to diesel. Further the effect of Rhodium oxide as a fuel

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additive with Pongamia oil and Pongamia pinnata biodiesels was investigated by S.Manibharathiet., [2] and concluded that the brake thermal efficiency is increased marginally compared to diesel, due to the better combustion in the combustion chamber.Experimental investigations on DI diesel engine with aluminum oxide nano additive with Zizipus jujube methyl ester biodiesel in various mass fractions of biodiesel blends was performed by C. Syed Aalamet. [3] and concluded that the emissions were drastically reduced with the high flow characteristics and inherent oxygen content of nano additive.

III. PRODUCTION OF JATROPHA OIL

The Jatropha plant has grown at any environmentalconditions in waste land at wide range.The preparation of Jatropha oil flow diagram is shown in figure below.

Figure1. Flow chart for production of Jatropha oil

IV. EXPERIMENTAL WORK

For the present experimental work avertical four stroke single cylinder water cooled constant speed, diesel engine equipped with AVL flue gas analyzer system is used. Using diesel,B20 biodiesel and blends with various proportions of aluminum oxide nanoparticle additive with Jatropha biodiesel blends as a fuel the performance and emission characteristics were obtained for various loads at constant speed of 1520 rpm at a constant injection timing of 23.4° bTDC (before Top Dead Centre).The engine has a belt brake dynamometer to measure its output. A constant load test is conducted and the results were recorded under steady stateconditions.The experimental setup used in experiment is shown in below figure. The specifications of the engine used in experiment and properties of fuel is mentioned in the following tables.

Figure2. Experimental Setup

Table1. Technical Specifications of the Engine

Make	**Kirloskar**
Type	4-stroke,1-cylinder diesel engine (water cooled)
Rated power output	5HP,1500 RPM
Bore & Stroke	80mm x 110mm
Compression Ratio	16.5:1
Dynamometer	Belt brake
Emissions	AVL Gas analyzer

Table2. Properties of Diesel and Jatropha biodiesel

S. No	**Properties**	**B20**	**Jatropha**	**Diesel**
1	Density (Kg/m^3)	856	880	850
2	Viscosity (mm^2/s)	3.0	4.8	2.6
3	Flash Point (°C)	73.4	127	60
4	Fire Point (°C)	77.4	131	64
5	Calorific Value (MJ/Kg)	41.5	39.2	43

Table 3 Properties of Aluminum Oxide nano additive

S. No.	**Properties**	**Aluminum oxide**
1	Density (Kg/m^3)	3900
2	Molecular Weight (g/mole)	101.96
3	Appearance	White solid
4	Flash Point (°C)	1500

At constant injection pressure the experiments were conducted for different loads. The performance and emission parameters of diesel,B20(80% diesel+20% Jatropha biodiesel) and B20 blended with

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the nano particles in the mass fraction of 50 ppm, 100 ppm and 150 ppm are compared with other blends.

The Jatropha oil is blended with diesel with the help of Magnetic stirrer with blending proportion of B20.The magnetic sterling process is carried out with constant speed.The blending process is as shown in figure below.

Figure3. Magnetic stirrer

The mixing of Aluminum oxide nano particle with Jatropha biodiesel is with the help of ultrasonicator to a frequency of 40 kHz and 120W for 60 minutes. The mixing process by using ultrasonicator is called ultrasonication.The ultrasonicator technique is an act of applying ultrasound to agitate the nano particles in the biodiesel. The same procedure is applied for blend of biodiesel with mass fractions of 50 ppm,100 ppm and 150 ppm of nanoparticles. The ultrasonication process is as shown in figure below

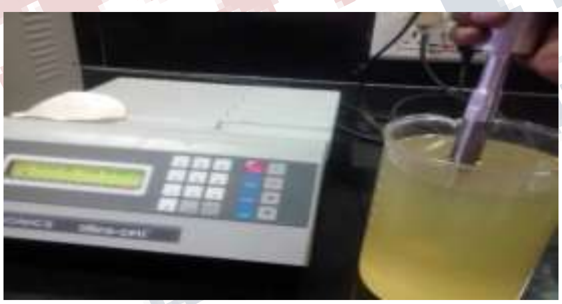

Figure4. Ultrasonicator for blending

V. REPLACEMENT OF PISTON IN THE ENGINE

The air motion in inside the engine cylinder is one of the most important factors for the combustion process. The air motion governs the air-fuel mixing and also burning rates in diesel engines. In the present work the experimental investigation of air turbulence in the cylinder upon the performance and emission of a single cylinder diesel direct injection is presented. This intensification of the turbulence is done by cutting six Rambus grooves on the crown of the piston(RGP6). Experiments are carried out on a diesel engine using Rhombus grooved pistons in a four stroke single cylinder water cooled and constant speed engine. Performance parameters such as brake powerand specific fuel consumption are calculated based on experimental analysis of the engine. To obtain a better combustion with lesser emissions in direct—injection diesel engines, it is necessary to achieve a good spatial distribution of the injected fuel throughout the entire space in combustion chamber. This requires matching of the injection fuel sprays with combustion chamber geometry. In other words, the combustion chamber geometry, fuel injection and air flows are the most crucial factors for attaining a better combustion in diesel engine. In direct injection diesel engines, turbulence can increase the rate of fuel-air mixing, reducing the combustion duration for re-entrant chambers at retarded injection timings. Turbulence with compression induced squish flow increases turbulence levels in the combustion bowl, promoting mixing. Since the flow in the combustion chamber develops from interaction of the intake flow with the in-cylinder geometry, the goal of this work is to characterize the role of combustion chamber geometry on in-cylinder flow, thus the fuel-air mixing, combustion and reduce pollutant formation processes in exhaust emissions.

VI. RHOMBUS GROOVED PISTON (RGP6):

In order to enhance the air turbulence inside the cylinder, six rhombus shaped grooves are made on the piston. The selected dimensions for the rhombus groove cutting are (10 x 5 x 2 mm) and the angle between consecutive grooves is $60^0$with six number of grooves on the piston head. The grooved piston is as shown in below figure

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Figure 5.Top view of the Rhombus Grove Piston Crown

VII. RESULTS AND DISCUSSIONS

The following results are obtained after testing the various blends of biodiesel at rated load by replacing the normal (Aluminum) piston with the grooved (Aluminum+ R6) piston in the engine. Based on the experiments it is concluded that B20+100ppm blend of biodiesel has better performance compare to other blends of biodiesel.

Brake Thermal Efficiency

The Brake thermal efficiency in grooved piston is increased by 6.14% compare to the diesel. In grooved piston the turbulence characteristics are improved due to presence of grooves in piston crown and further it enhance the combustion with homogeneous mixture formation and oxygen content in biodiesel compare to the normal piston.

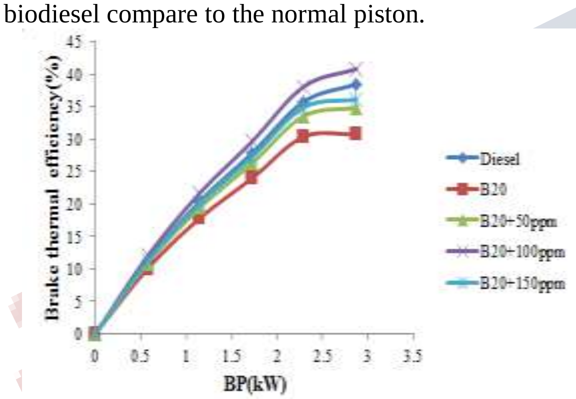

Figure 6. Variation of Brake thermal efficiency with B.P

Specific Fuel Consumption

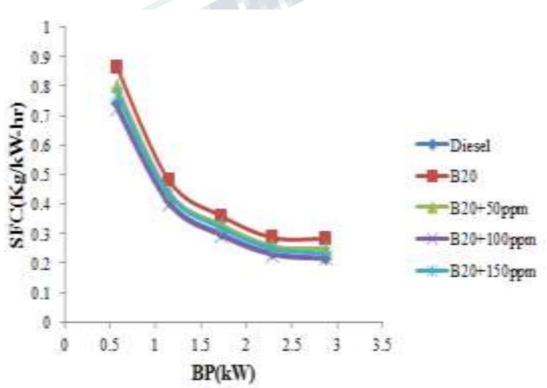

Figure7. Variation of Specific fuel consumption with B.P

The Specific fuel consumption is decreased by 4.37% compare to diesel.In grooved piston due to complete combustion the brake thermal efficiency is maximum. Hence complete fuel in the combustion chamber takes part in the combustion and so the specific fuel consumption is decreased. Additionally with the grooved piston the weight of the piston is decreased which further reduces the SFC.

HC Emissions

The formation of HC emissions is due to the wall quenching, improper mixing and incomplete combustion. With the turbulence in the combustion chamber homogeneous mixture forms which leads for the complete combustion and higher temperatures in the chamber. As more oxygen content is available with the biodiesel, the HC emissions are decreased by 14.81% compare to diesel.

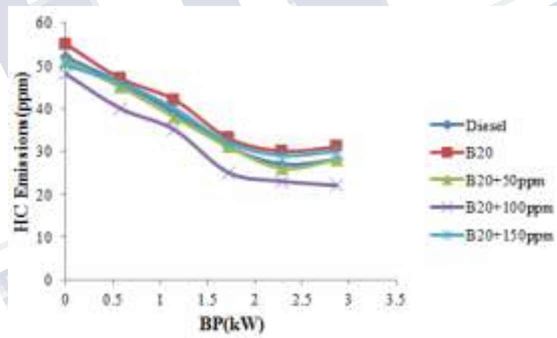

Figure8. Variation of HC Emissions with B.P

CO Emissions

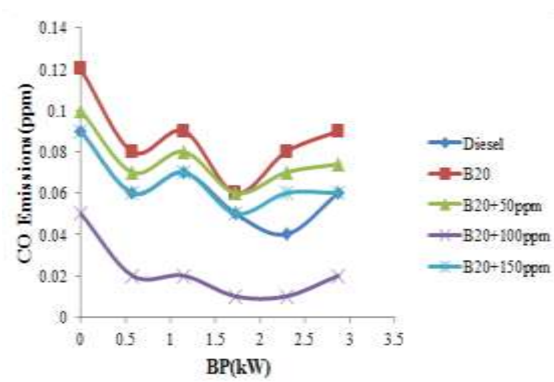

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Figure9. Variation of CO Emissions with B.P

The formation of CO emissions is due to the incomplete combustion and lack of sufficient oxygen content with the fuel. With the higher inherent oxygen content in the biodiesel, the carbon monoxide emissions formed will be oxidized and converts into carbon dioxide gas. Hence the CO emissions are decreased 19% compare to diesel. In grooved piston the air fuel ratio is equal to the stoichiometry air fuel ratio and also due to presence of grooves on piston crown the air get turbulent throughout the combustion chamber, the complete combustion takes place in the combustion chamber. So the CO emissions are decreased compare to diesel.

NO_x Emissions

At lower temperatures nitrogen acts as an inert gas and will be active at higher temperatures. With the grooved piston, there is good turbulence and homogeneous mixture formation in the combustion chamber. Hence the heat produced is more and with the higher oxygen content the NO_x emissions are increased by 4.3% compare to diesel.

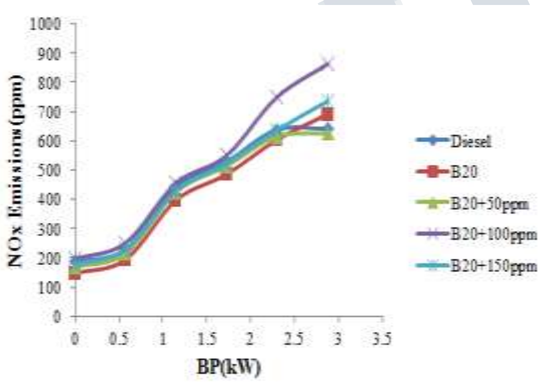

Figure10. Variation of NO_x Emissions with B.P

VIII. CONCLUSION

The performance and emission characteristics of diesel engine by replacing the normal piston with grooved piston is investigated with various blends of biodiesel as shown in graphs above. The blend B20+100 PPM shows better performance. The conclusions are as follows.

1. With the complete combustion in the chamber compare to normal piston, the Brake thermal efficiency of grooved piston is increased by 6.14% compare to diesel.
2. The Specific fuel consumption is decreased by 4.37%compare to diesel.
3. The HC emissions are decreased by 14.81% compare to diesel.
4. The CO emissions are decreased by 19% compare to diesel.
5. With the higher temperature in chamber, the NO_x emissions are increased by4.3%compare to diesel.

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