

Performance Characteristics of CI engine with Perovskite Composite Nanomaterial as Fuel Additive

Kalpna G. Joshi¹, S. B. Bajaj², Sumedh S. Ingle³

Research Scholar, Dr. B. A. M. U, Aurangabad, India¹

Lecturer, Sanjivani KBP, Polytechnic, Kopargaon, India¹

Associate Professor, JES College, Jalna, India²

Associate Professor, SRES, Sanjivani College of Engineering, Kopargaon, India³

ABSTRACT: The biggest problem of the 21st century is related with increasing price of mineral fuels, eventual depletion of fossil reserves and growing society related about global warming. Although of high prices of the diesel fuel, it's demand for transportation and agricultural purposes is increase in year by year. A renewable energy source in particular is capable of reducing our dependency on foreign import thus, increasing the security of energy demand. The biodiesel is the liquid fuel that can replace diesel without any major modification in existing diesel engine. The purpose of current research work is to study performance of palm and castor biodiesel with perovskite type composite nanomaterial as an additive. The result shows significant increase in performance by 40% - 48% with use of composite nanomaterial as an additive in biodiesel as compare to biodiesel without nanomaterial.

KEYWORDS: Palm biodiesel, Castor biodiesel, composite nanomaterial, perovskite etc.

I. INTRODUCTION

The availability of energy reservoir plays a vital role in the progress of a nation. Almost all the human energy needs at present are fulfilled from the rapidly depleting fossil fuels related with serious environmental consequences. Production and utilization of the bio fuel would generate new economic opportunities in term of creation of job opportunities in rural areas in addition to the protection of the environment. Biodiesel and ethanol derived from biomass feed stocks can provide alternative substitute of petrol diesel and gasoline respectively. Biodiesel can be obtained from a number of non edible and edible oil resources and major focus is given for the utilization of non edible seed plant. Biodiesel is an oxygen contained diesel engine fuel which can be obtained from vegetable oils or animal fats by conversion of the triglyceride esters via transesterification. It has similar properties to those of fossil diesel. Therefore, research on biodiesel derivate from vegetable oils and animal fats lead to the study of substitute to petroleum based diesel fuels [1][2][3]. It has been reported by the results of many studies that biodiesel can be used in diesel engines with minor or without any modifications, and with nearly the same performance. The results vary according to the animal fats or base vegetable oil, the method of biodiesel production as well as biodiesel fuel properties [4][5][6][7].

In the present study the biodiesel derived from palm, castor oil and combination of palm and castor oil with additives of perovskite type composite nanomaterial (BNN) and its blends with petroleum diesel at full load conditions, and at constant preheating temperatures are tested to derive an optimum fuel blend in terms of performance characteristics. The properties of Palm biodiesel are mentioned in Table no. 1 and properties of Castor Biodiesel in Table no. 2 [8-16].

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 11, November 2016

Table 2. Properties of Palm biodiesel

Calorific Value	36790 kJ/kg
Viscosity at 40 °C	4.1 mm ² /s
Specific gravity @ 15°C	0.875
Flash Point	175°C
Pour Point	-12°C
Cetane number	52
Density at @ 15°C	0.875 g/cm ³
Visual appearance	Dark Brown liquid

Table 1. Properties of Castor biodiesel

Calorific Value	37900.8 kJ/kg
Viscosity at 40°C	15.98 mm ² /s
Specific gravity at room temp.	0.888 kg/lit
Flash Point	190.7°C
Pour Point	-45°C
Cetane number	50
Density at room temp.	888 kg/ m ³
Visual appearance	Viscous pale yellow

II. EXPERIMENTAL SETUP

The experimentation was carried out on a single vertical cylinder, 4-stroke, single acting, totally enclosed, water-cooled, high speed compression ignition engine. The engine specifications are shown in Table no. 3. The engine was coupled by universal coupling to an Eddy Current Dynamometer. The engine and eddy current dynamometer were mounted on a common bed made from Iron C-Channel which was bolted to the cement foundation as shown if figure no. 1. In case of eddy current dynamometer, the loading is electrical i.e., by excitation current to the dynamometer coil.

Table 3. Engine Specifications

Make	Kirloskar
Type	Single Cylinder, 4 Stroke, C.I. diesel engine
C.R.	16.5:1
Stroke	110 mm
Bore	80 mm
Rated output	3.7 kW
BMEP at 1500 rpm	5.42 bar
Rated speed	1500 rpm
Dynamometer	Eddy current, water cooled with loading unit

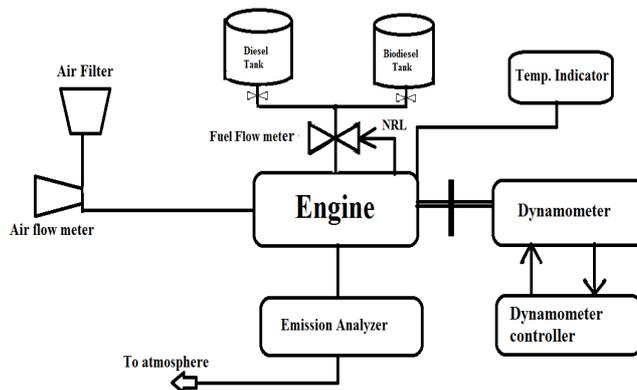


Fig.1. Experimental Setup

International Journal of Innovative Research in Science, Engineering and Technology

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III. EXPERIMENTATION

Experimentation was carried out in two parts i.e. synthesis of perovskite type composite nanomaterial and experimentation on CI engine for performance, with Biodiesel and then with Composite nanomaterial as Fuel additive.

A. SYNTHESIS OF COMPOSITE NANOMATERIAL

Perovskite Composite nanomaterial was synthesized by conventional solid state method [9]. The mixture of barium oxide, nickel oxide and niobium oxide (99% AR grade) were taken in the stoichiometric proportion for sample then it was crushed for 4 hours. This sample was then kept in the muffle furnace in the silica crucible at 600 degree Celsius for 12 hours. It was then cooled naturally and again crushed for 4 hours.

XRD of the BNN material was carried out which showed sharp single peaks as shown in figure no.2. This indicates the single phase nature of the sample with cubic structure.

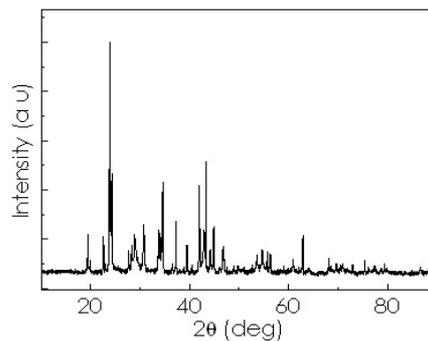


Fig. 2. X-ray diffraction pattern of Ba (Ni_{0.5}Nb_{0.5})O₃ Perovskite material

B. EXPERIMENTATION ON DIESEL ENGINE

Biodiesel (B100) and its blends B20, B40, B60, B80 & additive were used to test the engine at full load [5]. Initially 2 gm of nanomaterial per liter was mixed in biodiesel. This mixture was stirred for half hour with the help of Flocculator machine at 200 rpm as shown in figure no.3. The engine was stabilized for 10 minutes after each experimentation and then various parameters were recorded. The injection pressure of injector was kept 200 bar. The engine was loaded using the eddy current dynamometer gradually. The speed of the engine was sensed using a sensor pre-installed in the dynamometer and was note down from the display on the control panel of the dynamometer.



Fig. 3 Flocculator machine (for proper mixing of additives)

IV. RESULT AND DISCUSSION

A. BRAKE THERMAL EFFICIENCY

The variations of brake thermal efficiency with different blends of biodiesel and additive are represented in Fig. 4 5, 6, 7.

Fig.4. The graph predicts variation of BTE with respect to blends of Palm with additive. It is found that as blend ratio increases, brake thermal efficiency increases up to B80 later on it decreases at B100. The more BTE encountered at blend B80. Viscosity of Palm is less as well as BNN material is more dense so proper mixing of fuel i.e. optimization takes place and complete combustion occurs.

Fig. 5. The graph shows variation of BTE with respect to blends of Castor with additives. It is observed that the blend percentage increases the BTE also increases upto B100. It is found that B100 shows more BTE as compared to other blends. As blend B100 is more dense as compare to other blend, power produced is more.

Fig. 6. The graph shows variation of blends of palm, castor and additive. It predicts that initially BTE increases and then decreases. It is found that B60 blend of P+C+BNN shows more BTE. 60% palm reduces viscosity while 40 % castor gives more dense charge which in result gives maximum BTE at B60 blend.

Fig.7. the graph shows BTE of optimum biodiesel blend. It is found that Palm with additive B80 blend shows highest BTE. It is so because viscosity of palm provide proper mixing and optimization for combustion . Secondly BNN provides good turbulence in the combustion chamber.

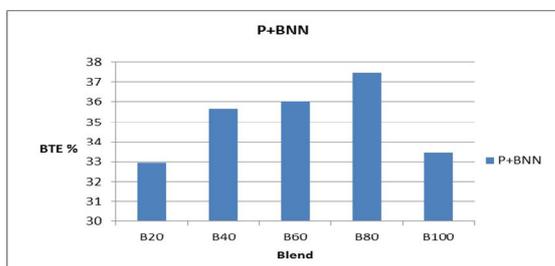


Fig.4 Graph of BTE Vs. Blend for P+A

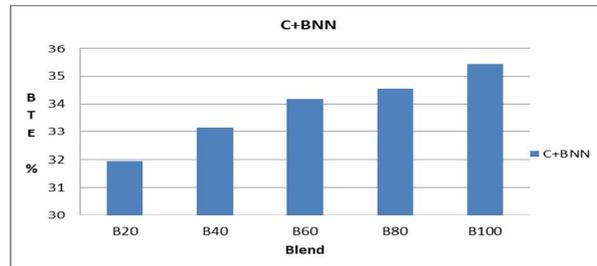


Fig.5 Graph of BTE Vs. Blend for C+A

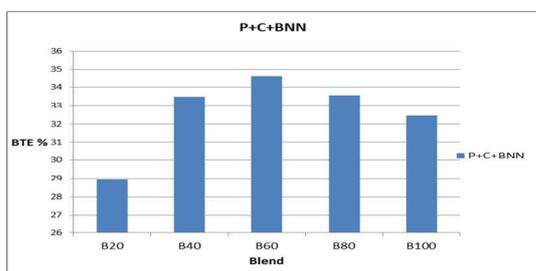


Fig.6 Graph of BTE Vs. Blend for P+C+A

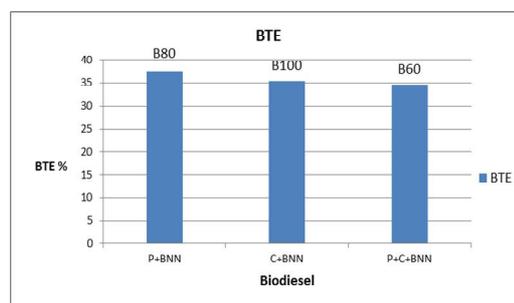


Fig.7 Graph of optimum BTE vs. Biodiesel and its Blend

B. BRAKE SPECIFIC FUEL CONSUMPTION

BSFC is a measure of combustion efficiency. BSFC with respect to different blends of Biodiesel are shown in Fig. 8, 9,10,11.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 11, November 2016

Fig.8. predicts the variation of BSFC with respect to blends of palm biodiesel with BNN as additive. It is observed that as the blend percentage increases the BSFC decreases and at B80 BSFC is minimum i.e. 0.245kg/kWh. This is because the fuel consumption at B80 is minimum as well as density is less.

Fig. 9. Shows the variation of BSFC versus castor with additive. It predicts that as blend percentage goes on increases BSFC goes on decreasing i.e. at B100 it is minimum. This is because density of castor is more as compared to palm and BNN.

Fig.10. Shows variation of BSFC with respect to blends palm castor and additive. It is observed that with increase in blend, BSFC decreases up to B60 then again increases till B100. The minimum BSFC is encountered at B60. This is because 60 % palm and 40% castor i.e. the average density will be less than castor also BNN helps for complete combustion.

Fig. 11. Graph represents the optimum BSFC variation with respect to biodiesel with additive. It is found that Biodiesel palm+ BNN shows lowest BSFC at blend B80. Since fuel consumption of palm with additive is lowest.

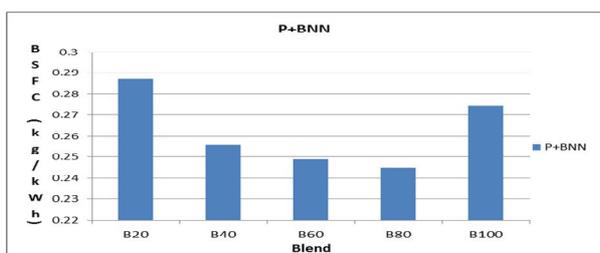


Fig. 8 Graph of BSFC vs. Blend for P+BNN

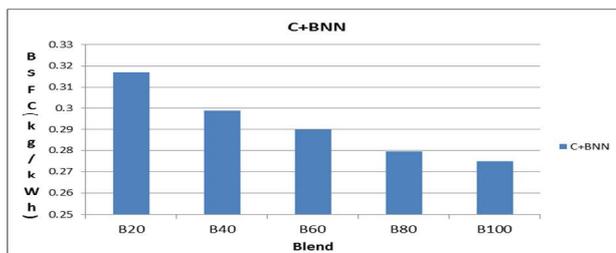


Fig. 9 Graph of BSFC vs. Blend for C+BNN

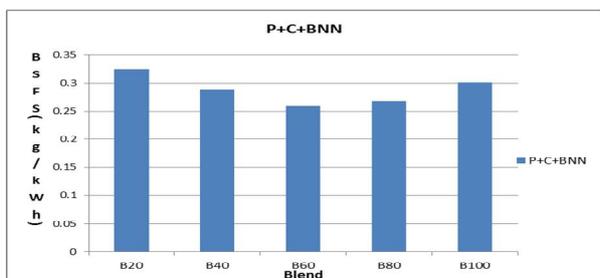


Fig.10 Graph of BSEC vs. Blend for P+C+BNN

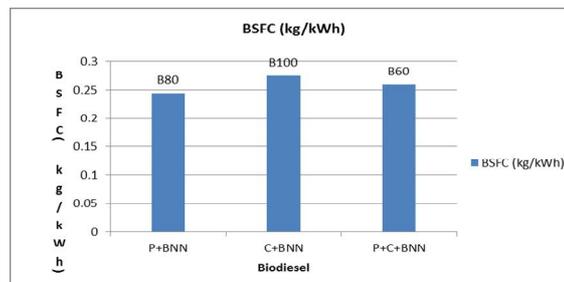


Fig.11 Graph of optimum BSFC vs. Biodiesel and Blend

V. CONCLUSIONS

In overall, B80 blend of palm biodiesel with BNN as an additive shows an optimized trend of performance enhancement. The use of palm oil creates a need to increase palm oil sources. Being bio-degradable, non-toxic, eco-friendly, sulphur free & renewable alternative fuel, biodiesel helps in arresting global warming. Local production of biodiesel will save a huge amount of foreign exchange. This capital when invested in country will improve our financial structure. The emissions from diesel engine, created health and welfare issues of human beings and on earth's environment. One of the positive efforts towards this problem is use of renewable energy source like Biodiesel and also the use of nanomaterial as additive .Which is effective because of enhancement of surface area to volume ratio. Also nanomaterial helps for complete combustion. Which reduces the emission and improves performance of diesel engine. Thus biodiesel with nanomaterial as an additive is a new era of fuel alternate to conventional fuel.

International Journal of Innovative Research in Science, Engineering and Technology

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ABBREVIATION

CI - Compression Ignition

CR - Compression ratio

BNN – Barium Nickel Niobium oxide($\text{BaNi}_{0.5}\text{Nb}_{0.5}\text{O}_3$)

B20(P) - Palm Biodiesel 20% + Diesel 80%

B40(C) - Castor Biodiesel 40% + Diesel 60%

B60(P+C) - Palm Biodiesel 60% + Castor Biodiesel 40%

B80(P+A) -Palm Biodiesel 80% + Diesel 20% + BNN nanomaterial additive

B100(C+A) - Castor Biodiesel 100% + BNN nanomaterial additive

BSFC - Brake specific Fuel consumption (kg/kWh)

BTE - Brake thermal efficiency (%)

A- Additive

ACKNOWLEDGEMENT

We would sincerely like to thank to shri A. D. Raut, IIT Mumbai for his help and cooperation in XRD testing of sample. Also Principal Dr. D. N Kyatanavar, and Vice Principal Dr. A.G.Thakur, SRES's, Sanjivani COE, Kopargaon for their motivation. Last but not the least Hon. Managing Trustee Shri Amit Dada Kolhe for moral support and providing us facility to carry out research work.

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