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Performance of CI Engine with Ceramic Oxide Coated Piston and Fuelled by Blended Rice Bran Oil

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ABSTRACT:

Due to depletion of fossil fuels, concerns about energy security and global warming make renewable energy resources more attractive. In this regard, using biodiesel seems to be a possible and feasible source of energy for transportation. This paper presents an investigation of the performance and emission characteristics of CI engine using 10% blend of rice bran oil as fuel and ceramic oxide coated piston.

KEYWORDS:

Rice bran oil; Ceramic coating; Piston; Performance; Emission

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NOMENCLATURE:

TFC	Total fuel consumption
SFC	Specific fuel consumption
BP	Brake power
BTE	Brake thermal efficiency
CO	Carbon monoxide
HC	Hydrocarbon

1. Introduction

An internal combustion engine (ICE) is an engine where the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. In an ICE the expansion of the high-temperature and high-pressure gases produced by combustion apply direct force to some component of the engine. The force is applied typically to pistons, turbine blades, or a nozzle. IC engines are seen every day in automobiles, trucks and buses. The diesel engine has the highest thermal efficiency of any standard internal or external combustion engine due to its very high compression ratio and inherent lean burn which enables heat dissipation by the excess air [1]. A small efficiency loss is also avoided compared to two-stroke non-direct-injection diesel engines since un-burnt fuel is not present at valve overlap and therefore no fuel goes directly from the intake/injection to the exhaust. In a compression ignition engine there is no spark to create the flame but rather high temperatures and pressures in the combustion chamber cause flame to initiate at different sites of the combustion chamber. Combustion increases with increasing pressure and temperature. The specifications of the diesel engine used in this study are presented in Table 1.

Table 1: Specifications of four stroke, single cylinder vertical air cooled diesel engine (Kirloskar oil engine TAF 1)

Property	Value
Rated power	4.4kW
Rated speed	1500rpm
Bore diameter (D), Stroke (L)	87.5mm, 110mm
Compression ratio	17.5 : 1
Orifice diameter	13.6mm
Coefficient of discharge (cd)	0.6
Calorific value fuel	42,500 kJ/kg

The piston is encapsulated within a combustion chamber. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. The piston is moved up and down by the rotary motion of the two arms or links. The crankshaft rotates which makes the two links rotate. The purpose of applying the coating may be decorative, functional, or both. Functional coatings may be applied to change the surface properties of the substrate, such as adhesion, corrosion resistance, or wear resistance. Thermal spraying technology has been widely used for zirconium oxide (ZrO_2) coating of metallic structures. Adhesion is a very important factor determining the life of coated parts. The effectiveness of coating depends on the substrate preparation. Very few papers have specifically dealt with the effect of preparation on adhesion. The thermal barrier coating is usually a multilayer system consisting of a ceramic topcoat, a metallic bond coat and a super alloy substrate. The properties of ZrO_2 coating material is presented in Table 2. High deposition rates of ZrO_2 coatings are possible without huge investments on capital equipment.

Table 2: Chemical properties of Zirconium

Property	Value
Atomic number	40
Atomic mass	91.22 $g.mol^{-1}$
Pauling electro negativity	1.2
Density	6.49$g.cm^{-3}$ at 20°C
Melting point	1852°C
Boiling point	4400°C
Vander waals radius	0.160 nm
Isotopes	11

Rice bran oil is a unique vegetable oil produced from the outer brown layer of rice which is removed in the form of rice bran during the polishing process of the rice milling industry [2]. Bran is a hard outer layer of grain. Rice bran oil content ranges from 12-10% depending upon the quality of the bran. Chemical refining of rice bran oil generally results in losses considerably higher than those encountered in other vegetable oils due to the presence of larger amounts of free fatty acids and non-triacylglycerol constituents [3-4]. The calorific value and density of blended diesel (90% diesel 10% rice bran oil) are 9706 kJ/kg and 842.7 kg/cc at 15°C respectively [5]. Various researchers [6-10] have investigated the use of rice bran oil blended with diesel towards performance and emission control analysis using standard diesel engine. In this work, the effects of zirconium oxide coated piston use as well as the use of diesel blended with 10% rice bran oil have been experimentally assessed to determine the fuel consumption, brake thermal efficiency, mechanical efficiency and various emissions.

2. Methodology

The experimental tests are conducted using four stroke diesel CI engine, in the following steps:

- STEP 1: The performance value and readings were taken by using standard piston and neat diesel fuel (identified as “PD”).
- STEP 2: The performance value and readings were taken by using standard piston and 10% of rice bran oil blended with 90% diesel (identified as “R10”).
- STEP 3: The performance value and readings were taken by using zirconium oxide coated piston and neat diesel fuel (identified as “CD”).
- STEP 4: The performance value and readings were taken by using zirconium oxide coated piston and 10% of rice bran oil blended with 90% diesel (identified as “CR10”).

The brake power in kW can be calculated using,

$$BP = 1000 * V * I * \Phi / \eta \quad (1)$$

Where V is voltage, I is current in Ampere and η = 0.9 is the generator efficiency and Φ = 1 is the power factor. The indicated power in kW is given by,

$$IP = BP + FP \quad (2)$$

Where FP is fuel power and can be obtained from BP vs. TFC curves. The TFC in kg/hr is given by,

$$TFC = Q * \rho / t \quad (3)$$

Where Q is the volume of fuel consumption, ρ is the density of diesel, 860 kg/m^3 and t is the time taken for 10 cc of fuel consumption. The SFC in kg/kW hr is give by,

$$SFC = TFC / BP \quad (4)$$

The mechanical efficiency in % is given by,

$$\chi = 100 * BP / IP \quad (5)$$

The BTE in % is given by,

$$BTE = 100 * CV * BP / TFC \quad (6)$$

Where CV = 43500 kJ/kg is the calorific value of the fuel [5]. The indicated thermal efficiency % is given by,

$$ITE = 100 * CV * IP / TFC \quad (7)$$

3. Result and discussion

Fig. 1 shows the BP vs. TFC. The TFC is said to be 21.80% for PD case, 23.21% for R10 case, 27.77% for CD case, which is said to be highest fuel consumption and 27.22% for CR10 case. Fig. 2 represents the BP vs. SFC. The SFC is said to be 21.17% for PD case, 14.8% for R10 case, 8.44% for CD case, 8.25% for CR10 case. The optimum result is obtained for 90% of diesel and 10% of rice bran oil without coating of piston as 16.39%. Fig. 3 presents the BP vs. BTE. The BTE is said to be 22.83% for PD case, 31.34% for R10 case, 17.74% for CD case, 28.09% of CR10 case. The optimum result is obtained for R10 case. Fig. 4 represents the BP vs. mechanical efficiency, 26.54% for PD case, 27.48% for R10 case, 22.26% for CD case and 23.72% for CR10 case. The optimum result is obtained for R10 case.

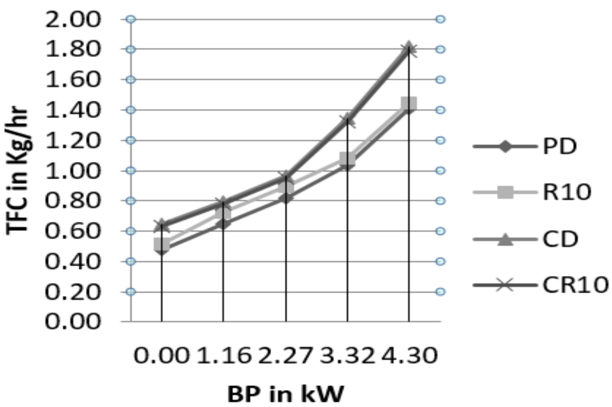

Fig. 1: BP vs. TFC

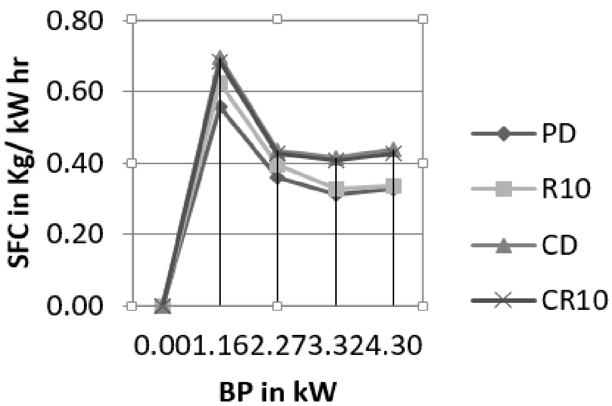

Fig. 2: BP vs. SFC

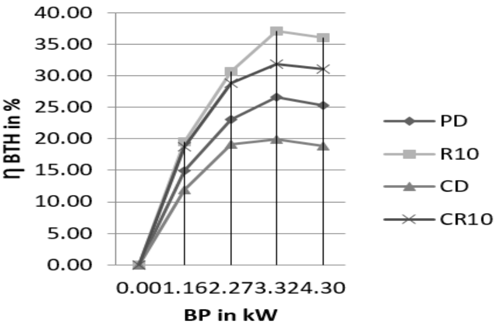

Fig. 3: BP vs. Brake thermal efficiency

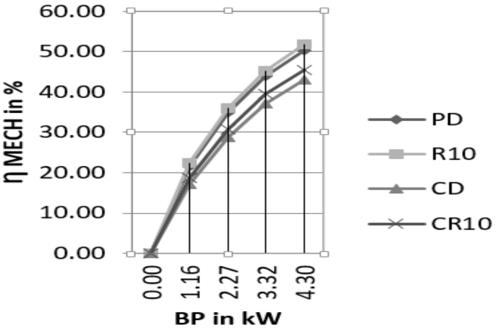

Fig. 4: BP vs. Mechanical efficiency

Fig. 5 represents the BP vs. CO_2 emissions, 24.19% for PD case, 24.19% for R10 case, 26.11% for CD case and 25.51% for CR10 case. The optimum result is obtained for PD and R10 cases. Fig. 6 presents the BP vs. CO emissions, 21.31% for PD case, 16.39% for R10 case, 35.25% for CD case and 27.05% for CR10 case. The optimum result is obtained for R10 case. Fig. 7 shows the BP vs. unburned HC emissions, 37.92% for PD case, 15.41% for R10 case, 23.11% for CD case and 23.56% for CR10 case. The optimum result is obtained for R10 case.

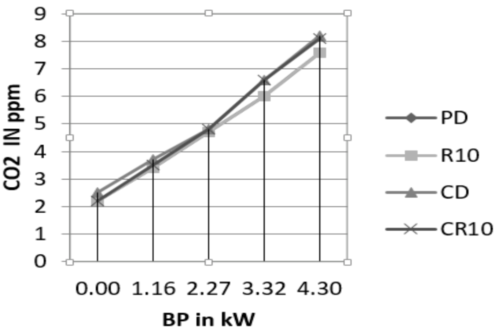

Fig. 5: BP vs. CO_2 emissions

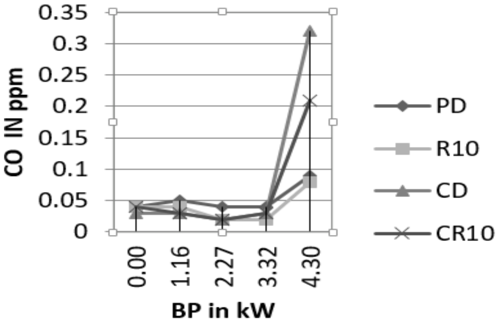

Fig. 6: BP vs. CO emissions

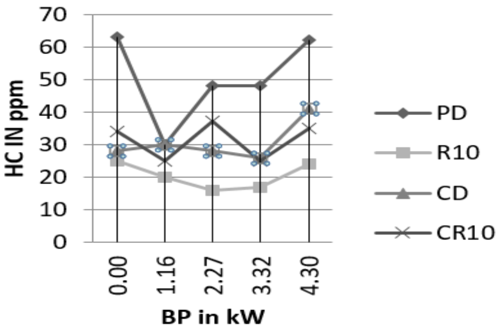

Fig. 7: BP vs. HC emissions

4. Conclusion

In this paper the use of blended rice bran oil as fuel in CI engine with ceramic oxide coated piston was investigated through experiments. Various emission characteristics were also assessed. It is concluded that the best optimum result is obtained as 23.21% for TFC, 16.39% for SFC, 31.34% for BTE, 27.48% for mechanical efficiency for 10% of rice bran oil blended with 90% of diesel and without coating of piston with respect to the performance characteristics. In case of emission characteristics, the optimum result is obtained as 24.19% for CO_2, 16.39% for CO, 15.41% for HC for the case of 10% of rice bran oil blended with 90% of diesel and without coating of piston. Further directions of research include the root cause analysis for limited influence of ZrO_2 coated piston on the performance and emissions of CI engines fuelled with biodiesel.

REFERENCES:

[1] A.M. Ashraful, H.H. Masjuki, M.A. Kalam, I.M.R. Fattah and H.M. Mobarak. 2014. Production and comparison of fuel properties, engine performance, and emission characteristics of biodiesel from various non - edible vegetable oils: A review, *Energy Conversion and Mgmt.*, 80, 202-228. https://doi.org/10.1016/j.enconman.2014.01.037.

[2] N.E.L. Boulifi and A. Bouaid. 2013. Optimization and oxidative stability of biodiesel production from rice bran oil, *Renewable Energy*, 53, 141-147. https://doi.org/10.1016/j.renene.2012.11.005.

[3] C.E.C. Rodrigues, C.B. Gonçalves, E.C. Marcon, E.A.C. Batista and J.A. Antonio. 2014. Meirelles deacidification of rice bran oil by liquid - liquid extraction using a renewable solvent, *Separation and Purification Tech.*, 132, 84-92. https://doi.org/10.1016/j.seppur.2014.05.009.

[4] K. Tomita, S. Machmudah, Wahyudiono, R. Fukuzato, H. Kanda, A.T. Quitain, M. Sasaki and M. Goto. 2014. Extraction of rice bran oil by supercritical carbon dioxide and solubility consideration, *Separation and Purification Tech.*, 125, 319-325. https://doi.org/ 10.1016/j.seppur.2014.02.008.

[5] I. Lamprecht. 1999. Combustion Calorimetry, *Handbook of Thermal Analysis and Calorimetry*, 4, 175-218.

[6] Ch. Narasimha and M. Rajesh. 2013. Performance and emission characteristics of diesel engine fuelled with rice bran oil, *Int. J. Engg. Trends and Tech.*, 4(10).

[7] N.D.P. Rao and M.V.S.M. Krishna. 2014. Effect of injector opening pressure and injection timing on exhaust emissions and combustion characteristics of rice bran oil in crude form and biodiesel form in direct injection diesel engine, *J. Engg.*, 4(2), 9-19.

[8] G. Arunkumar and A. Santhoshkumar. 2013. Performance and emission characteristics of low heat rejection diesel engine fuelled with rice bran oil biodiesel. advanced material research, *Energy Efficient Technologies for Sustainability*, 245-249.

[9] G. Dhamodaran and R. Krishnan. 2017. A comparative study of combustion, emission and performance characteristics of rice bran - neem - and cottonseed - oil biodiesels with varying degree of unsaturation, *Fuel*, 187, 296-305. https://doi.org/10.1016/j.fuel.2016.09.062.

[10] V.K. Kaimal and P. Vijayabalan. 2017. A detailed investigation of the combustion characteristics of a DI diesel engine fuelled with plastic oil and rice bran methyl ester, *J. The Energy Institute*, 90(2), 324-330. https://doi.org/10.1016/j.joei.2015.11.005.