Study of Effect of Different Biodiesel blends (70% Diesel + 30% Biodiesel) on Tribological Property of IC Engine components

Dr. Venkata Sundar Rao K[#1], Dr. Shreeprakash B[#2]

[#1]Post Doctoral Fellow, [#2]Professor & Head, Dept. of Mechanical Engineering, Srinivas University College of Engineering & Technology, Mangaluru, India

Abstract - The internal combustion (IC) engine is a heat engine that converts chemical energy into mechanical energy, usually made available on a rotating output shaft. Chemical energy of the fuel is first converted to thermal energy by means of combustion or oxidation with air inside the engine. This thermal energy raises the temperature and pressure of the gases within the engine, and the high-pressure gas then expands against the mechanical mechanisms of the engine. This expansion is converted by the mechanical linkages of the engine to a rotating crankshaft, which is the output of the engine. The crankshaft, in turn, is connected to a transmission and/or power train to transmit the rotating mechanical energy to the desired final use. For engines this will often be the propulsion of a vehicle. The wear test reveal the effect of different Biodiesel blends (70% Diesel + 30% Biodiesel) on Tribological Property of IC Engine components viz., piston, piston rings and cylinder liner. From the above discussions it is clearly evident that blend of 70% diesel + 30% Hippe oil has better lubrication properties exhibited as compared to diesel and other blends of biodiesels considered.

Keywords - Diesel, Hippe oil, Surface roughness.

I. INTRODUCTION

Internal combustion engines are seen every day in automobiles, trucks, and buses. The name internal combustion refers also to gas turbines except that the name is usually applied to reciprocating internal combustion (I.C.) engines like the ones found in everyday automobiles. There are basically two types of I.C. ignition engines, those which need a spark plug, and those that rely on compression of a fluid. Spark ignition engines take a mixture of fuel and air, compress it, and ignite it using a spark plug. The name`reciprocating' is given because of the motion that the crank mechanism goes through. The piston- cylinder engine is basically a crank-slider mechanism, where the slider is the piston in this case. 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 piston is encapsulated within a combustion chamber. The bore is the diameter of the chamber. The valves on top represent induction and exhaust valve necessary for the intake of an air-fuel mixture and exhaust of chamber residuals.

Parts of the Engine Block

- Cylinder – the part of the engine block where the combustion takes place.
- Piston – a plunger with rings that fit against the inside cylinder walls and prevent air from leaking past
- Connecting rod – connects the piston to the crankshaft. Fastened by the wrist pin
- Crankshaft – shaft with offsets to which the connecting rods are attached

The large increase in number of automobiles in recent years has resulted in great demand for petroleum products. With crude oil reserves estimated to last only for few decades, there has been an active search for alternate fuels. The depletion of crude oil would cause a major impact on the transportation sector. Of the various alternate fuels under consideration, biodiesel, derived from vegetable oils, is the most promising alternative fuel to conventional diesel fuel (derived from fossil fuels; hereafter just "diesel") due to the following reasons

- Biodiesel can be used in existing engines without any modifications.
- Biodiesel is made entirely from vegetable sources; it does not contain any sulfur, aromatic hydrocarbons, metals or crude oil residues.
- Biodiesel is an oxygenated fuel; emissions of

 DOI : 10.35291/2454-9150.2020.0632

carbon monoxide and soot tend to be reduced compared to conventional diesel fuel.

• Unlike fossil fuels, the use of biodiesel does not contribute to global warming as CO_2 emitted is once again absorbed by the plants grown for vegetable oil/biodiesel production. Thus CO_2 balance is maintained.

• The Occupational Safety and Health Administration classify biodiesel as a non-flammable liquid.

• The use of biodiesel can extend the life of diesel engines because it is more lubricating than petroleum diesel fuel.

• Biodiesel is produced from renewable vegetable oils/animal fats and hence improves fuel or energy security and economy independence.

A lot of research work has been carried out using vegetable oil both in its neat form and modified form. Studies have shown that the usage of vegetable oils in neat form is possible but not preferable . The high viscosity of vegetable oils and the low volatility affects the atomization and spray pattern of fuel, leading to incomplete combustion and severe carbon deposits, injector choking and piston ring sticking. Methods such as blending with diesel, emulsification, pyrolysis and transesterification are used to reduce the viscosity of vegetable oils.

II. LITERATURE REVIEW

Wang Wenzhong, HU Yuanzhong, WANG Hui & LIU Yuchuan [1] they have found that Piston and piston ring lubrication is a factor that strongly affects the performance of the reciprocating internal combustion engine. Their work is based on a unified numerical approach assuming that the pressure distribution obeys Reynolds equation in hydrodynamic lubrication regions while in asperities contact regions, the contact pressure can be obtained through the so called reduced Reynolds equation.

Arka Ghosh [2] has worked on the essentials of combustion chamber, their design, influence in combustion process, timing, etc. They emphasize research on newer designs requirement for combustion chambers.

Balvinder Budania1and Virender Bishnoi [3] developed „A New Concept of I.C. Engine with Homogeneous Combustion in a Porous Medium‟. They have proposed a new combustion concept that fulfils all requirements to perform homogeneous combustion in I.C. engines using the Porous Medium Combustion Engine, called “PM - engine”.

S. Jaichandar and K. Annamalai [4], has discussed the effect of use of biodiesel fuel on engine power, fuel consumption and thermal efficiency are collected and analyzed with that of conventional diesel fuel.

Maro JELIĆ and Neven NINIĆ [5], discussed the „Analysis of Internal Combustion Engine Thermodynamic Using the Second Law of Thermodynamic‟. They applied the numerical simulations in modeling the ICE engine processes together with the analysis by the second law of thermodynamics, they got a very potent tool for better insight and optimization of spark- and compression-ignition engines achieving lower fuel consumption and lower emissions.

N.H.S.Ray, M.K.Mohanty and R.C.Mohanty [6] have worked on Biogas as Alternate Fuel in Diesel Engines‟. They reviewed the current status and perspectives of biogas production, including the purification & storage methods and its engine applications. Lower hydrocarbon (HC), smoke and particulates emission has been reported in diesel engines operating on biogas diesel dual fuel mode.

C D Rakopoulos, E G Giakoumis, and D C Rakopoulos [7] have discussed the Study of the short-term cylinder wall temperature oscillations during transient operation of a turbo- charged diesel engine with various insulation schemes. The work investigates the phenomenon of short-term temperature (cyclic) oscillations in the combustion chamber walls of a turbocharged diesel engine during transient operation after a ramp increase in load. The investigation reveals many interesting aspects of transient engine heat transfer, regarding the influence that the engine wall material properties have on the values of cyclic temperature swings.

Er. Milind S Patil, Dr. R. S. Jahagirdar, and Er. Eknath R Deore [8] have worked on Performance Test of IC Engine Using Blends of Ethanol and Kerosene with Diesel. They used 3.75 kW diesel engine AV1 Single Cylinder water cooled, Kirloskar Make to test blends of diesel with kerosene and Ethanol. This paper presents a study report on the performance of IC engine using blends of kerosene and ethanol with diesel with various blending ratio. Parameters like speed of engine, fuel consumption and torque were measured at different loads for pure diesel and various combination of dual fuel. Break Power, BSFC, BTE and heat balance were calculated. Paper represents the test results for blends 5% to 20%.

M. Lackner, F. Winter [9] have discussed the Laser Ignition in Internal Combustion Engines. Laser ignition tests were performed with the fuels hydrogen and biogas in a static combustion cell and with gasoline in a spray-guided internal combustion engine. A Nd:YAG laser with 6 ns pulse duration, 1064 nm wavelength and 1-50 mJ pulse energy was used to ignite the fuel/air mixtures at initial pressures of 1-3 MPa. Compared to a conventional spark plug, a laser ignition system should

 DOI : 10.35291/2454-9150.2020.0632

ISSN : 2454-9150 Vol-06, Issue-07, OCT 2020

be a favorable ignition source in terms of lean burn characteristics and system flexibility. Yet several problems remain unsolved, e.g. cost issues and the stability of the optical window.

Sutaria B.M, Bhatt D.V and Mistry K.N [10] has worked on study of basic tribological parameters that influences performance of an internal combustion engine. Mathematical model is developed using average Reynolds equation. Parametric study is performed on 150 CC, 2 Stroke Internal Combustion Engine. The oil film thickness (OFT), piston friction forces (PFF), and Ring friction variations are simulated under different variable i.e engine speed, lubricants and different ring geometry. The simulated results of piston friction force, ring friction force and oil film thickness are compared with published literature.

III. METHODOLOGY

In the present study, the mechanical property viz., the wear of the piston, piston ring and cylinder liner is investigated. The duration of test is considered for 2 hours, 4 hours and 6 hours run of the engine. The corresponding readings of surface roughness (R_a) values of the piston, piston ring and cylinder liner have been recorded by using the surface measurement test. The measuring points considered at top dead center (TDC), bottom dead center (BDC) and mid of TDC and BDC (MID).

IV. RESULTS AND DISCUSSION

The results have been tabulated for the R_a values considering the conditions of 100% Diesel (B0), blend of 70% Diesel + 30% Honge oil (H30), blend of 70% Diesel + 30% Hippe oil (M30) and blend of 70% Diesel + 30% Rice Bran oil (R30) and the positions of the measurements for different components of the IC Engine.

The comparison of the R_a values is done to investigate the surface roughness of the IC Engine components considered for the study. The duration of the test considered is 2 hours, 4 hours and 6 hours running of IC Engine.

The data pertaining to the R_a values for Cylinder liner positions are tabulated in Table 1. The average of circumferential measurement points is taken to plot the variation of R_a values and is shown in the Figure 1.

Table 1 R_a Value of Cylinder liner with Diesel (B0) and different Biodiesels (70% Diesel + 30% Biodiesel)

Cylinder Liner Positions	R_a values in microns											
	2 Hrs (B0)	2 Hrs (H30)	2 Hrs (M30)	2 Hrs (R30)	4 Hrs (B0)	4 Hrs (H30)	4 Hrs (M30)	4 Hrs (R30)	6 Hrs (B0)	6 Hrs (H30)	6 Hrs (M30)	6 Hrs (R30)
Liner TDC	0.415	0.456	0.375	0.414	0.469	0.457	0.377	0.461	0.37	0.459	0.311	0.473
Liner MID	0.204	0.372	0.192	0.382	0.244	0.377	0.215	0.384	0.27	0.218	0.205	0.41
Liner BDC	0.694	0.583	0.571	0.594	0.785	0.598	0.574	0.601	0.573	0.622	0.513	0.632

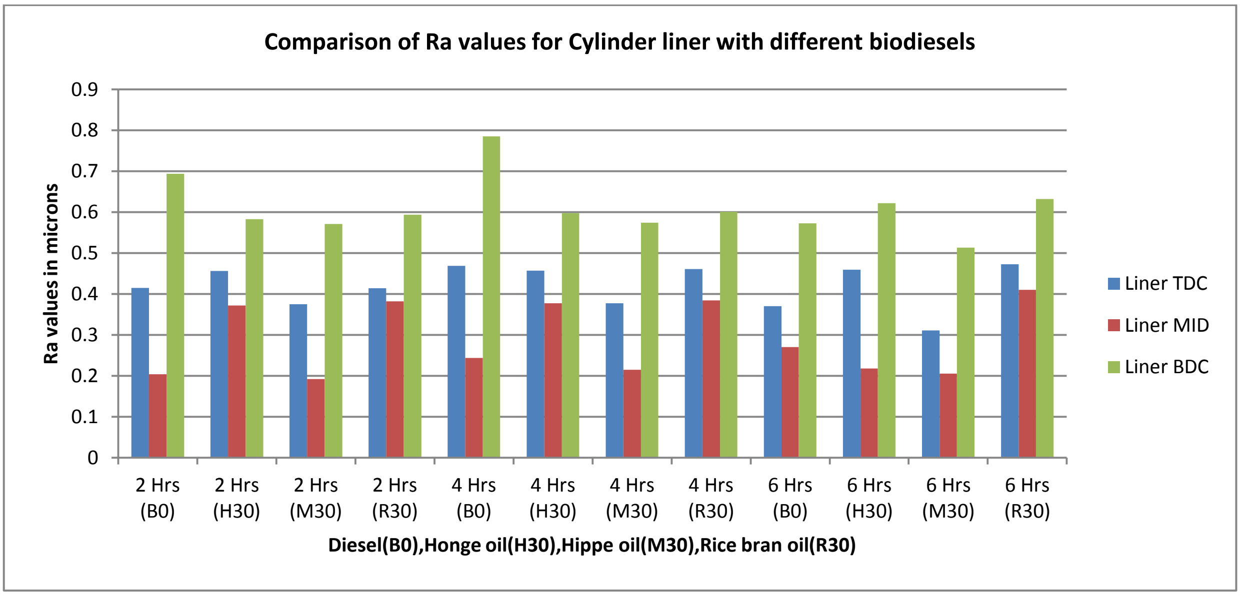

Figure 1 Comparison of R_a Value for Cylinder liner with Diesel (B0) and different Biodiesels (70% Diesel + 30% Biodiesel)

DOI : 10.35291/2454-9150.2020.0632

ISSN : 2454-9150 Vol-06, Issue-07, OCT 2020

From the Figure 1 it can be concluded that R_a value of 0.192 microns is minimum at cylinder liner MID position for 2Hrs run with Hippe oil (M30). By using M30 biodiesel it is observed that there is an improvement of tribological properties of the components.

The data pertaining to the R_a values for piston are tabulated in Table 2. The average of two measurement points is taken to plot the variation of R_a values and is shown in the Figure 2.

Table 2 R_a Value for piston with Diesel (B0) and different Biodiesels (70% Diesel + 30% Biodiesel)

Piston Positions	R_a values in microns											
	2 Hrs (B0)	2 Hrs (H30)	2 Hrs (M30)	2 Hrs (R30)	4 Hrs (B0)	4 Hrs (H30)	4 Hrs (M30)	4 Hrs (R30)	6 Hrs (B0)	6 Hrs (H30)	6 Hrs (M30)	6 Hrs (R30)
Piston TDC	0.566	0.561	0.49	0.511	0.478	0.437	0.261	0.341	0.37	0.317	0.257	0.340
Piston Land	0.366	0.351	0.241	0.321	0.243	0.244	0.201	0.245	0.27	0.238	0.198	0.312
Piston Skirt	0.652	0.551	0.331	0.612	0.236	0.378	0.209	0.241	0.573	0.365	0.200	0.211

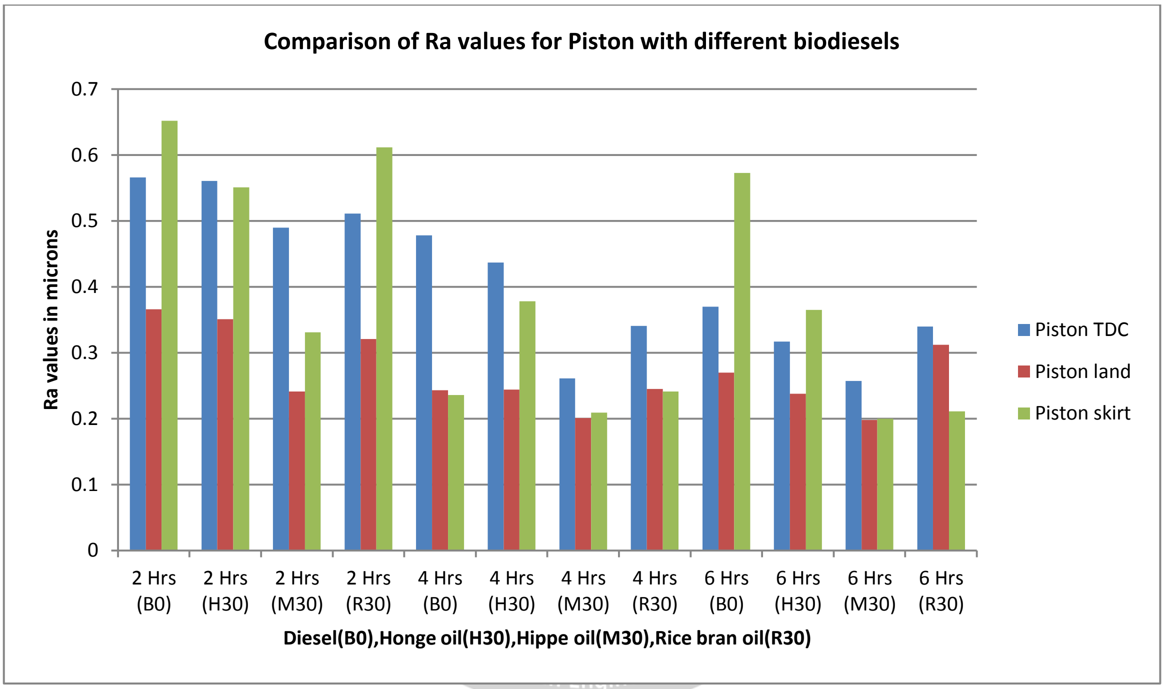

Figure 2 Comparison of R_a values for piston positions with Diesel (B0) and different Biodiesels (70% Diesel + 30% Biodiesel)

From the Figure 2 it can be concluded that R_a value of 0.198 microns is minimum at Piston Land position for6Hrs run with Hippe oil (M30). For piston also M30 biodiesel recorded the minimum amount of wear compared to blends of biodiesel.

The data pertaining to the R_a values for piston rings are tabulated in Table 3. The average of two measurement points is taken to plot the variation of R_a values and is shown in the Figure 3.

Table 3 R_a Value for piston ring with Diesel (B0) and different Biodiesels (70% Diesel + 30% Biodiesel)

Piston Rings	R_a values in microns											
	2 Hrs (B0)	2 Hrs (H30)	2 Hrs (M30)	2 Hrs (R30)	4 Hrs (B0)	4 Hrs (H30)	4 Hrs (M30)	4 Hrs (R30)	6 Hrs (B0)	6 Hrs (H30)	6 Hrs (M30)	6 Hrs (R30)
Ring 1	0.73	0.18	0.09	0.19	0.72	0.19	0.039	0.18	0.086	0.35	0.049	0.19
Ring 2	0.65	0.19	0.101	0.21	0.37	0.20	0.09	0.27	0.134	0.25	0.059	0.27

DOI : 10.35291/2454-9150.2020.0632

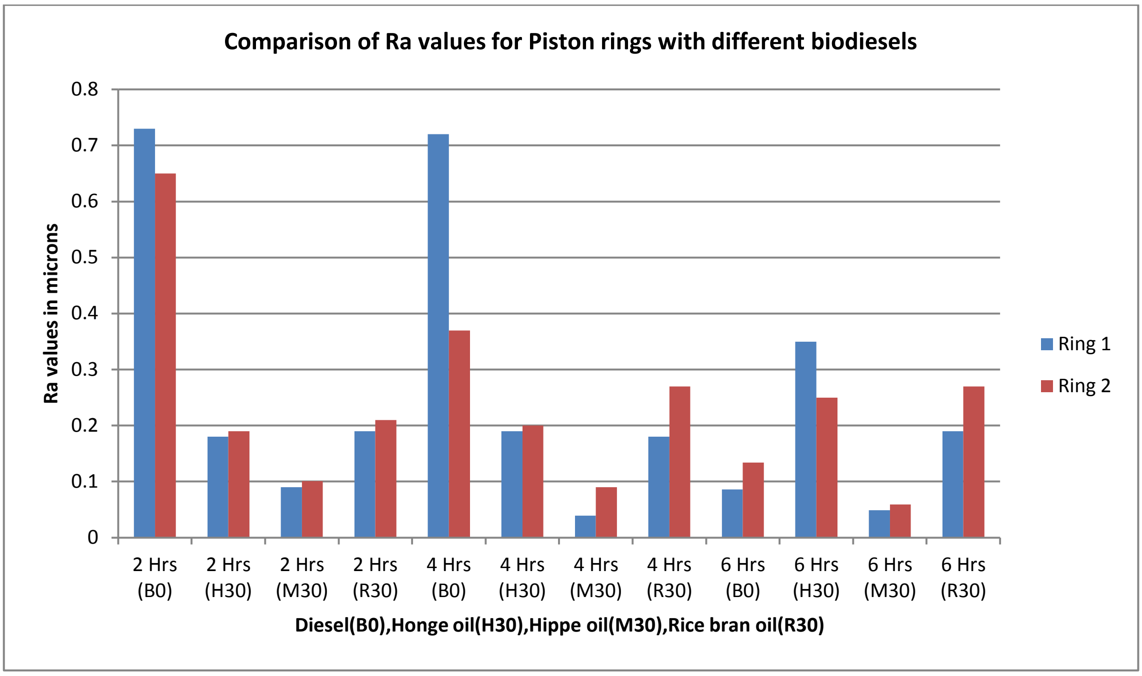

Figure 3 Comparison of R_a values for piston rings with Diesel (B0) and different Biodiesels (70% Diesel + 30% Biodiesel)

From the Figure 3 it can be concluded that R_a value of 0.039 microns is minimum for piston ring1 position for 4Hrs run with Hippe oil (M30). Likewise with M30 biodiesel, rings also experiences minimum wear than other blends.

V. CONCLUSION

The wear test reveal the effect of different Biodiesel blends (70%Diesel + 30%Biodiesel) on Tribological Property of IC Engine components viz., piston, piston rings and cylinder liner. From the above discussions it is clearly evident that blend of 70% diesel + 30% Hippe oil has better lubrication properties exhibited as compared to diesel and other blends of biodiesels considered.

REFERENCES

[1]WANG Wenzhong, HU Yuanzhong, WANG Hui & LIU Yuchuan, „Numerical simulation of piston ring in the mixed lubrication‟ State Key Laboratory of Tribology, Tsinghua University, Beijing 100084, China, 2001

[2] ARKA GHOSH, „COMBUSTION CHAMBERS IN CI ENGINES‟ SRM University

[3]Balvinder Budania, Virender Bishnoi, „A New Concept of I.C. Engine with Homogeneous Combustion in a Porous Medium‟ International Journal of Latest Trends in Engineering and Technology (IJLTET)

[4]S. Jaichandar and K. Annamalai, „The Status of Biodiesel as an Alternative Fuel for Diesel Engine‟ Journal of Sustainable Energy & Environment 2 (2011) 71-75

[5]Maro JELIĆ and Neven NINIĆ, „Analysis of Internal Combustion Engine Thermodynamic Using the Second Law of Thermodynamics‟85-94 (2008)

[6]N.H.S.Ray, M.K.Mohanty and R.C.Mohanty, „Biogas as Alternate Fuel in Diesel Engines‟ IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 9, Issue 1 (Sep. - Oct. 2013), PP 23-28 www.iosrjournals.org

[7]C D Rakopoulos, E G Giakoumis, and D C Rakopoulos, „Study of the short-term cylinder wall temperature oscillations during transient operation of a turbo- charged diesel engine with various insulation schemes‟ 4 February 2008

[8]Er. Milind S Patil, Dr. R. S. Jahagirdar, and Er. Eknath R Deore, „Performance Test of IC Engine Using Blends of Ethanol and Kerosene with Diesel‟ International Journal of Engineering Science and Technology Vol. 2(8), 2010, 3503-3509

[9]M. Lackner, F. Winter, „Laser Ignition in Internal Combustion Engines - A Contribution to a Sustainable Environment‟ Institute of Chemical Engineering, Vienna University of Technology, Getreidemarkt 9/166, A-1060 Wien, Austria

[10] Sutaria B.M, Bhatt D.V and Mistry K.N, „Simulation and Modeling of Friction Force and Oil Film Thickness in Piston Ring – Cylinder Liner Assembly of an I. C. Engine‟ Proceedings of the World Congress on Engineering 2009 Vol II WCE 2009, July 1 - 3, 2009, London, U.K.

 DOI : 10.35291/2454-9150.2020.0632