Study of the Effect of Biofuel on Tribological Property of IC Engine Components

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Abstract

The importance of the alternative fuels is gaining importance as the design change of combustion process is very minimum or negligible. Hence it is apparent that the study of the factors which affecting the performance and the credibility of the engine as well. There are several researches undergoing to study the performance of the engines using well-known alternative fuels include biodiesel, bioalcohol (methanol, ethanol, butanol), refuse-derived fuel, chemically stored electricity (batteries and fuel cells), hydrogen, non-fossil methane, non-fossil natural gas, vegetable oil, propane and other biomass sources. These bio fuels are chemical fuels as the fossil fuels and generate heat to perform mechanical work, hence, are the most desirable alternative to the fossil fuels. But the existing design of the combustion engines must sustain the same operating parameters, material strength of the different components and emission of the engine as that of the fossil fuel run engine. The studies reveal that the combustion performance and the emission are within the acceptable norms and are better than the fossil fuel run engines. Further, the studies on the mechanical properties of the different components have to be emphasized to understand whether the existing engines could be used using the alternative fuels. In the present work, the wear studies of the piston and cylinder are considered for the investigation. The surface roughness (R_a) values for piston, piston ring and cylinder linear of the engine is measured for both diesel (fossil fuel) and alternative fuel (blended 20% Honge oil + 80% Diesel). The results reveal that Ra value is improved significantly for the fuel blended with Honge oil compared to Diesel. Hence the blending of the bio fuels not only reduces the emission but also helps in maintaining the mechanical properties of the components of the engine.

Keywords — *Alternative fuels, Honge oil, Diesel, Surface roughness.*

I. INTRODUCTION

In internal combustion engine (IC Engine) the different components typically the piston experiences force due to high-temperature and high-pressure gases produced by combustion and then this force is transferred to some component of the engine to transform chemical energy into useful mechanical energy. Liquid fuels have over the past 100 years evolved as the fuels of choice for transport because of their high energy density and the ease of transport, storage and handling. Conventional fuels are complex mixtures that typically contain more than hundred chemical components whose composition has changed and evolved over time and in connection to engine development. The development has been done in correlation with and in order to meet the engine development demand on power, efficiency and drivability. The stringent emission norms by Governments, for controlling the emission by combustion of fossil fuels, initiated the demand for new designs. These designs emphasize on the use of alternative fuels to replace or to blend with the fossil fuels so as to minimize the cost of design changes. The mechanical properties of the materials used for the IC Engine components are considered to be the main objective of the studies to understand the effect of blending the alternative fuels with fossil fuels. However, the fuel in an internal combustion engine undergoes other processes and passes many systems before it is burned, as shown in Fig. 1, and these also have to be considered. All the systems will influence the fuel and the fuel's different properties will influence the systems.

Producing biodiesel from the vegetable oils is not a new process. Scientists E. Duffy and J. Patrick performed it as early as 1853. Rudolph Diesel designed the original diesel engine to run on vegetable oil. Rudolph Diesel the inventor of the engine that bears his name, experimented with fuels ranging from powdered coal to peanut oil, and used peanut oil to fuel one of his engines at the Paris Exposition of 1900. Because of the high temperature created, the engine was able to run a variety of vegetable oils including hemp ad peanut oil. At the 1911 world's Fair in Paris, Dr. R. Diesel ran his engine on peanut oil and declared "the diesel engine can be fed with vegetable oils and will help considerably in the development of the agriculture of the countries which use it". One of the first uses of transesterified vegetable oil was powering heavy-duty vehicles in South Africa before World War II. The use of vegetable oils as alternative renewable fuel competing with petroleum was proposed in the beginning of 1980s. The advantages of vegetable oils as diesel fuel are: liquid nature-portability, ready availability, renewability, higher heat content, lower sulfur content, lower aromatic content and biodegradability.

Bio diesel fuel is a renewable substitute fuel for petroleum diesel or petro diesel fuel made from vegetable or animal fats. Bio diesel fuel can be used in any mixture with petro diesel fuel as it has very similar characteristics but it has lower exhaust emissions. The major part of all energy consumed worldwide comes from fossil sources (petroleum, coal and natural gas). However, these sources are limited, and will be exhausted by the near future. Thus, looking for alternative sources of new and renewable energy such as hydro, biomass, wind, solar, geothermal, hydrogen and nuclear is of vital importance. Alternative new and renewable fuels have the potential to solve many of the current social problems and concerns, from air pollution and global warming to other environmental improvements and sustainability issues Vegetable oil is one of the renewable fuels. Vegetable oils have become more attractive recently because of its environmental benefits and the fact that it is made from renewable resources. Vegetable oils are a renewable and potentially inexhaustible source of energy with an energetic content close to diesel fuel. The vegetable oil fuels were not acceptable because they were more expensive than petroleum fuels. However, with recent increases in petroleum prices and uncertainties concerning petroleum availability, there is renewed interest in vegetable oil fuels for diesel engines. The use of vegetable oils as alternative renewable fuel competing with petroleum was proposed in the beginning of 1980s.

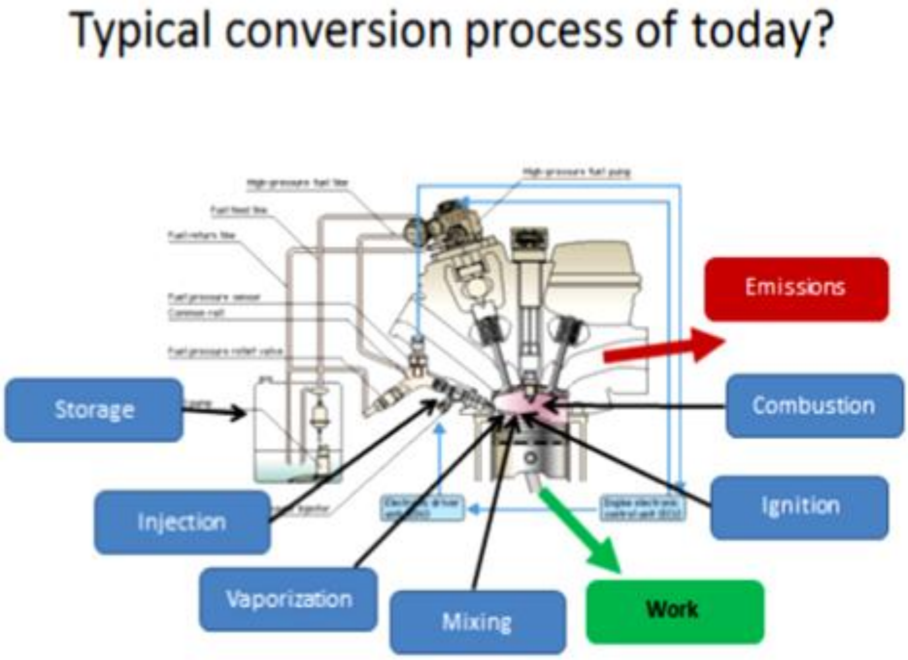

Fig. 1: Fuel path through an internal combustion engine[Google Images]

II. LITERATURE REVIEW

All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified. The review of research work on alternative fuels and combinations on the wear of the Piston, Piston Rings and Liners has been carried out. After going through the review, the objectives of the present research work have been implemented by setting up and experimental test rig. Some of the contributions have been discussed in the following paragraphs.

N.H.S.Ray, M.K.Mohanty and R.C.Mohanty [1] 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 [2] 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 [3] 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 [4] 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 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 [5] 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.

Wang Wenzhong, HU Yuanzhong, WANG Hui& LIU Yuchuan [6] 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.

ArkaGhosh [7] 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 VirenderBishnoi [8] 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 [9], have 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 [10], have 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.

III. METHODOLOGY

In the present work the mechanical property viz., the wear of the piston, piston ring and cylinder liner is investigated. The experiments have been conducted using diesel and then the fuel is blended with Honge oil. The detail of the study is given in the Table 1.

TABLE I
DETAILS OF FUELS USED FOR THE INVESTIGATION

Case No	% of Diesel	% of Honge Oil
1	100	0
2	80	20

The duration of test is considered for 2 hours and 4 hours run of the engine. The corresponding readings of surface roughness (Ra) values of the piston, piston ring and cylinder liner have been recorded by using the surface measurement test equipment shown in the Fig. 2. The measuring points considered at top dead center (TDC), bottom dead center (BDC) and mid of TDC and BDC (MID).

Fig. 2. Surface Roughness Measuring Test Equipment

IV. RESULTS AND DISCUSSIONS

The results of the test have been tabulated for the R_a values considering the conditions of 100% diesel and blend of 80%Diesel + 20% Honge oil and the positions of the measurements for different components of the IC Engine are as follows;
a. cylinder liner –five circumferential points at TDC, MID, BDC positions b. piston–two positions on the TDC, two positions on the land and two positions on the skirt c. piston ring -five circumferential points for two compression rings.

The comparison of the R_a values is done to investigate the wear of the IC Engine components considered for the study. The duration of the test considered is 2 hours and 4 hours running of IC Engine. The data pertaining to the R_a values for cylinder liner are tabulated in Table II.

The average of five circumferential measurement points is taken to plot the variation of R_a values. It is observed from the Figure 3 that the wear is more near the BDC region than the TDC region. The surface roughness value of 0.785 microns at BDC, for running the IC Engine for 4 hours using diesel, is more as compared to that of 0.62 microns for 4 hours running of IC Engine using the blend of 80% diesel + 20% Honge oil. This clearly indicates that the wear of the cylinder liner is at lower levels when the blend of of 80% diesel + 20% Honge oil is used.

TABLE II - RA VALUES OF THE CYLINDER LINER

Circumferential Points of Measurement	R_a Average value (2 Hrs run) Diesel (in microns)	R_a Average value (2 Hrs run) 80%Diesel+20%Honge oil (in microns)	R_a Average value (4 Hrs run) Diesel (in microns)	R_a Average value (4 Hrs run) 80%Diesel+20%Honge oil (in microns)
TDC	0.415	0.458	0.469	0.338
MID	0.204	0.398	0.244	0.392
BDC	0.694	0.682	0.785	0.62

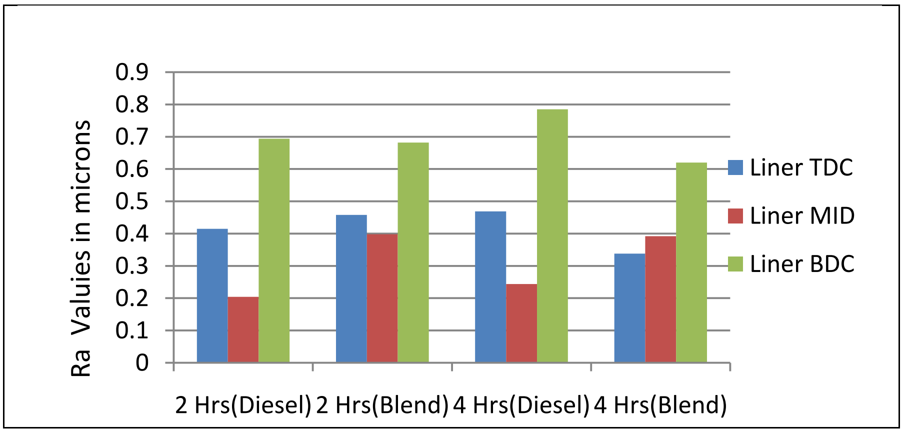

Fig. 3. Comparison of Ra values for Liner

The data pertaining to the R_a values for piston are tabulated in Table III. It is observed from the Figure 4 that the wear is more near the BDC region than the TDC region. The surface roughness value is more when the IC Engine is run for 2 hours using diesel as compared to 2 hours run using the blend of 80% diesel + 20% Honge oil.
The surface roughness value using diesel and using the blend of 80% diesel + 20% Honge oil for 4 hours run of IC Engine almost remains same. The piston at TDC and skirt region is observed the higher wear of the material of the Ra values of 0.566 microns and 0.652 microns.

TABLE III - R_a VALUES OF THE PISTON

Circumferential Points of Measurement	R_a Average value (2 Hrs run) Diesel (in microns)	R_a Average value (2 Hrs run) 80%Diesel+20%Honge oil (in microns)	R_a Average value (4 Hrs run) Diesel (in microns)	R_a Average value (4 Hrs run) 80%Diesel+20%Honge oil (in microns)
TDC	0.566	0.333	0.478	0.311
LAND	0.366	0.239	0.243	0.544
SKIRT	0.652	0.3396	0.236	0.3212

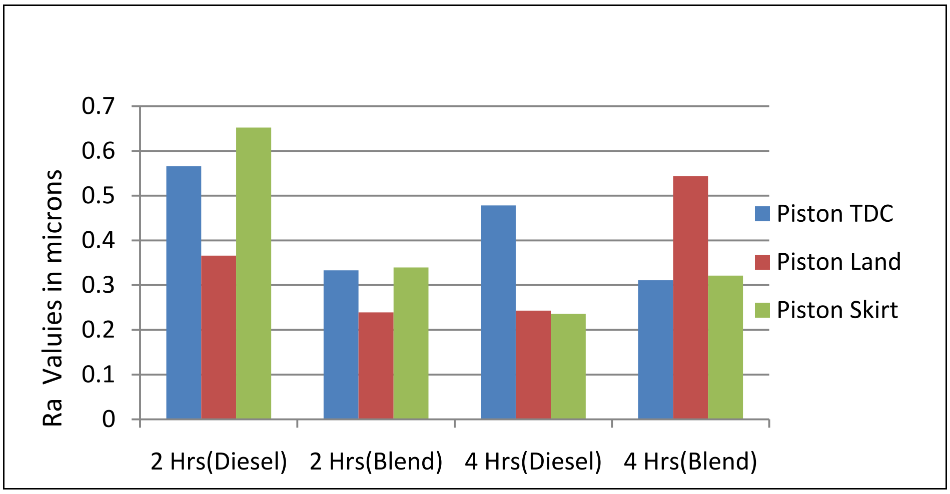

Fig. 4. Comparison of Ra values for Piston

The data pertaining to the R_a values for piston rings are tabulated in Table IV. It is also observed from the Figure 5 that the surface roughness values are more for the diesel as compared to the blend of 80% diesel+ 20% Honge oil on the piston rings. The overall value of surface roughness R_a, is reduced for the blend of 80% diesel+ 20% Honge oil taking all the IC Engine parts together.

TABLE IV - RA VALUES OF THE PISTON RINGS

Circumferential Points of Measurement	R_a Average value (2 Hrs run) Diesel (in microns)	R_a Average value (2 Hrs run) 80%Diesel+20%Honge oil (in microns)	R_a Average value (4 Hrs run) Diesel (in microns)	R_a Average value (4 Hrs run) 80%Diesel+20%Honge oil (in microns)
Ring 1	0.73	0.36	0.72	0.54
Ring 2	0.65	0.22	0.37	0.04

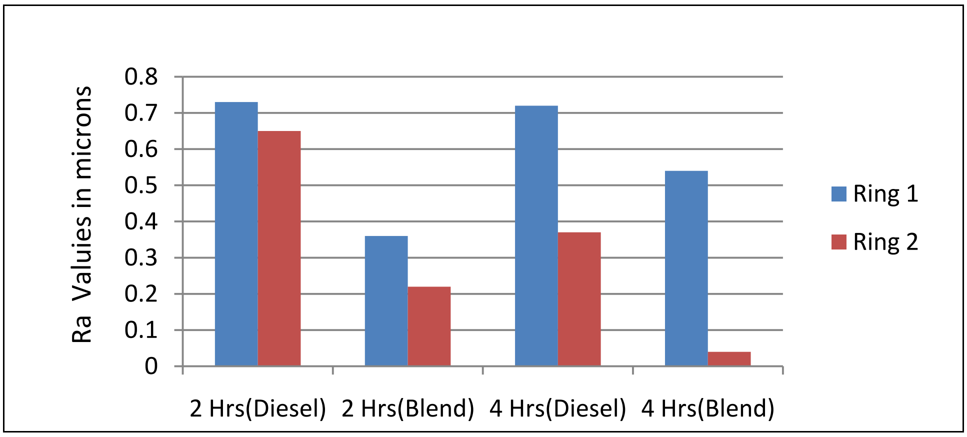

Fig. 5. Comparison of Ra values for Piston Ring

V. CONCLUSIONS

The wear test reveal the effect of the combustion of diesel and blend of 80% diesel+ 20% Honge oil on the wear of the materials of the IC Engine components viz., piston, piston rings and cylinder liner. In the present study the surface roughness of the IC Engine components has been recorded for diesel and blend of 80% diesel+ 20% Honge oil. The use of the blend of 80% diesel+ 20% Honge oil has better tribological properties of the IC Engine components as compared to the diesel as a fuel. Hence the blend of 80% diesel+ 20% Honge oil could be used as an alternative bio-fuel to reduce the pollution effects on the environment.

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