Impact of Bio-diesel fuel on Durability of CI Engines – A Review

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Abstract. Bio-diesel is a sustainable, renewable and alternate fuel for CI Engines. The use of bio-diesel produces various durability issues on key components of CI engines. For durability studies, the aspects considered are injector coking, carbon deposition on piston, lubricity of engine oil, wear and tear of piston and cylinder walls and corrosion of engine parts they come in contact with fuel. In this work, reports about the durability aspects, published by highly rated journals in scientific indexes, have been cited. From these reports, the effect of bio-diesel on engine durability are surveyed and analysed. The use of bio-diesel leads to injector coking, increased carbon deposition on piston, decreased viscosity of the lubricating oil and fuel dilution, increased engine wear and increased corrosion.

1. Introduction

The depletion of fossil fuel has made to look for alternative fuels. Among alternative fuels, biodiesel is more convenient to use for IC engines as it does not require any major engine modification. Its contribution towards global warming is lesser than that of diesel. The emission of unburned hydrocarbon (HC) and carbon monoxide are less in case of biodiesel because of complete combustion. But NOx emissions are more because of higher combustion temperature. The power produced is less due to the loss of heating value of biodiesel as compared to diesel. Durability is the ability of an entity to perform until limiting value is reached under conditions of use and maintenance. The various aspects considered in studying the durability of engine are injector coking, carbon deposits on piston and cylinder head, wear and tear of engine components, corrosion of engine parts that come in contact with biodiesel.

Biodiesel causes injector coking as it deposits more carbon on injector tip and injector nozzle. The deterioration of lubricating oil of biodiesel fuelled engine is more compared to diesel fuelled engine. The wear of engine components is more in biodiesel fuelled engine. The amount of carbon deposition on piston and cylinder head is also more in biodiesel fuelled engine. Very less research has been done on durability of engine as it is more time consuming. This paper reviews the works already made in the above aspects for biodiesel fuelled engines.
2. Durability Aspects

The following durability aspects are discussed in this section.

2.1. Injector coking and Fuel filter clogging:

A.M. Liaquat et al. [1] studied effect of J20 (20% biodiesel blend) Jatropha biodiesel on injector nozzle deposit when engine was run for 250 hours. It was observed that injector running with J20 is dirtier than that of diesel fuelled engine. Dry deposits were observed on the injector nozzle when the engine was running with J20 whereas oily/greasy deposits were observed on injector nozzle in the engine which was running with diesel. On and around the injector tip dark deposits were observed. These deposits nearly cover injector nozzle. Large carbon deposits were observed in the dark areas.

K A Sorate et al. [2] reported about fuel filter clogging when the engine was made run for 250 hours using Jatropha biodiesel. Since biodiesel has spectacular solvent property that allows impurities, and carries away through fuel system, causes fuel filter clogging. About 40% weight increase was observed with biodiesel filter compared to diesel fuelled engine.

2.2. Degradation of Lubricating Oil

K Nantha Gopal et al. [4] made comparative study on lubricating oil which was drawn from engine which was run by diesel and biodiesel (Pongamia Methyl Ester) (B20) for 256 hours each. Lubricating oil properties like kinematic viscosity, density, total base number, moisture content, pentane and benzene insoluble of lubricant drawn from diesel and biodiesel fuelled engine were compared. Kinematic viscosity and flash point of lubricating oil are highly reduced, in the oil which was drawn from biodiesel fuelled engine that indicates the degradation of lubricating oil as it is used. Due to biodiesel fuel dilution in to the lubricating oil, it shows higher corrosiveness and poor oil film strength.

The density and ash content of biodiesel operated engine’s lubricating oil is high compared to diesel operated engine’s lubricating oil because of contamination, wear debris and ash content. Total Base number of PME fuelled engine is reduced more than that of diesel fuelled engine suggesting higher depletion of anticorrosion additives and contamination of lubricating oil. Higher Pentane and Benzene insoluble in PME 20 fuelled engine is the reason for higher wear of the moving parts and depletion of lubricating oil.

Avinash Kumar Agarwal et al. [5] studied the effect of Karanja biodiesel on life of lubricating oil. They have reported that lubricating oil degradation rate was very high in biodiesel fuelled engine, which causes higher wear of bearings. Levent Yuksel et al. [6] studied the effect of Diesel and RME (Rapeseed Methyl Ester) on performance of lubricating oil by running the engine for 150 hours. Lubricating oil of RME fuelled engine aged faster than the diesel fuelled engine, also TBN and viscosity values are decreased by 29% and 60% respectively in biodiesel fuelled engine when compared to diesel fuelled engine. K A Sorate et al. [2] conducted test on engine for 512 hours for plane diesel and B100 biodiesel. It has been reported that the biodiesel has better lubricity than diesel. Long term endurance test causes higher biodiesel fuel dilution in to the lubricating oil which reduces the viscosity and that causes higher wear.

Yong-Yuan Ku et al. [7] tested the engine which was run for 500 hours at full load using B2 bio-diesel (2 volume %) which was prepared using spent edible oils, and obtained results such that lubricating oil of biodiesel fuelled engine deteriorated slower than that of diesel fuelled engine because of fewer deposition of sulphur, phosphor and zinc of carbon. A.K. Hasannuddin et al. [8] studied the effect of emulsion biodiesel (10% and 20%) on durability of engine. Diesel fuelled engine lubricating oil has slightly less viscosity compared to emulsion fuelled engine.
A.M. Liaquat et al. [1] carried out endurance test for 250 h each for both diesel and Jatropha biodiesel J20 (20%). Lubricating oil viscosity is decreased at higher rate in biodiesel fuelled engine compared to diesel fuelled engine.

2.3. Carbon Deposition on the piston

Yong-Yuan Ku et al. [7] reported that for biodiesel fuelled engine carbon deposits on the top of the piston was more compared to diesel fuelled engine. They observed looser carbon deposit on the piston of diesel fuelled engine that could be easily peeled off. A K Hasannuddin et al. [8] studied carbon deposition for Diesel, emulsion fuel with 10% (E10) and 20% (E20). The amount of carbon deposited for E10 and E20 were less than that for Diesel by 65% and 52% respectively. Among E10 and E20, E10 deposits less carbon.

2.4. Wear and tear of components that come in contact with bio-diesel

Metals like Fe, Cr, Al, Zn, Cu, Ni and Mg are expected in lubricating oil samples. Piston rings, cylinder head, valves, camshaft, Crank shaft, cylinder block, valve guide, wrist pin, bearings and rust from the environment are the possible source for Fe. The source of chromium could be from rings wear, cooling system leakage, chromium plated liner, shaft and gear. The sources of Aluminium may be piston, push rods, oil pump, bearing, and crank case oil paint. Lubricating oil itself is the source for zinc, as zinc-dialkyl Dithio phosphate is added to it, as it is anti-oxidant, corrosion inhibitor detergent and anti-wear. Injector shields, thrust washers, valve guides, connecting rod, piston rings, bushings and bearings are the contributors of copper in lubricating oil. Nickel may be developed from bearing, valves and gear plating. Wear of gears and cylinder liners are the sources of magnesium, additive added to lubricating oil is also source of magnesium.

K Nantha Gopal et al. [4] reported wear debris of Fe, Cr, Al, Zn, Cu, Ni and Mg were more in lubricating oil samples which were drawn from biodiesel (Pongamia Methyl Ester) fuelled engine. Since the biodiesel has poor lubricity, it results in higher wear of engine components. A.M. Liaquat et al. [1] reported higher concentration of metallic parts in the lubricating oil which was drawn from the J20 (Jatropha) biodiesel fuelled engine. Avinash Kumar Agarwal et al. [5] reported for Karanja biodiesel, rate of wear for most engine components is almost similar to diesel fuelled engine.

Levent Yuksel et al [6] showed higher rate of wear of engine components in the report, for usage of Rape seed oil methyl ester (RME). K A Sorate et al. [2] reported that wear of Top Ring, Compression Ring, Scrap Ring and oil ring is more in biodiesel fuelled engine compared to diesel fuelled engine. Zbigniew J. Sroka et al. [9] reported that Rape methyl ester does not affect the wear of cylinder liner and piston rings, wear level differences were there in slide bearings. Yong-Yuan Ku et al. [7] showed B2 (2% Biodiesel) did not have influence on the engine component size. When microscopic observation was made B2 biodiesel has slightly better character than diesel. L. G Schumacher et al. [3] also showed wear metals of B2 biodiesel fuelled engine appeared lower when compared with diesel fuelled engine. A K Hasannuddin et al. [8] tested the engine using emulsion fuel for 10% and 20% blends and concluded acceptable wear in emulsion fuelled engine.

2.5. Corrosion Behaviour of biodiesel

K A Sorate et al [2] reported that the biodiesel is more corrosive than diesel. Increase in biodiesel concentration and the level of oxidation will increase corrosive nature. The corrosive nature of biodiesel is also increased due to presence of water and impurities. Copper alloys are easily affected by corrosion compared to ferrous and aluminium alloys. Biodiesel severely affects lead alloy coating on tern steel sheet.
3. Conclusion
Based on the analysis of reports of different authors following conclusions are drawn.

1. The amount of carbon deposition on injector tip, injector nozzle is more in biodiesel fuelled engine. The fuel filter clogging takes place in biodiesel fuelled engine which is absent in case of diesel fuelled engine.
2. The deterioration of lubricating oil is less in low blend biodiesel whereas it is high in higher blended biodiesel. But emulsion fuel gives good results as deterioration of lubricating oil is less compared to diesel fuel.
3. The amount of carbon deposition on piston and cylinder head is more in biodiesel fuelled engine compared to diesel fuelled engine.
4. The wear of engine components is higher in high blended biodiesel compared to diesel fuelled engine and is less in low blended biodiesel compared to diesel fuelled engine as it acts as lubricant at low blends.
5. The corrosiveness of biodiesel is more as it contains water impurities.

References
[1] Liaquat A M, Masjuki H H, Kalam M A and Rizwanul Fattah I M 2014 Impact of biodiesel blend on injector deposit formation Energy 72 813-823
[2] Sorate K A and Bhale P V 2013 Impact of biodiesel on fuel system materials durability Journal of Scientific & industrial research 72 48-57
[3] Schumacher L G, Van Gerpen J and Brian T Adams 2003 Diesel fuel injection pump durability test with low level biodiesel blends ASAE Meeting Presentation
[4] Nantha Gopal K and Thundil Karuppa Raj R 2015 Effect of ponagmia oil methyl ester-diesel blend on lubricating oil degradation of di compression ignition engine Fuel JFUE 9715 1-10
[5] Avinash Kumar Agarwal and Atul Dhar 2013 Experimental investigations on effect of karanja biodiesel on engine performance, combustion and durability in collaboration with shell technology India private limited DIRECTIONS 93-100
[6] Levent Yuksek, Hakan Kaleli, Orkun Ozener and Berk Ozoguz 2009 The effect and comparison of bio-diesel fuel on crankcase oil, diesel engine performance and emissions FME transactions 37 91-97
[7] Yong-Yuan Ku, Ching-Fu Liao, Yu-Tsen Shih and Min-Tsang Chang The impact upon durability of heavy-duty diesel engine using low percentage biodiesel (B2)
[8] Hasannuddin A K, Wira J Y, Sarah S, Ahmad M I, Aizam S A, Aiman M A B, Watanabe S, Hirofumi N and Azrin M A 2016 Durability studies of single cylinder diesel engine running on emulsion fuel Energy 94 557-568
[9] Zbigniew J. Sroka 2007 Durability of engine components due to alternative fuels Eksplotacj Neuzaowodno c nr 4 9-15