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Impact of biodiesel and LPG on injector deposit formation

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ABSTRACT

The ever-increasing fossil fuel usage and cost, environmental concern has forced the world to look for alternative biofuel in compression ignition engine. In this research work, a 60 hours endurance test has been carried out on horizontal type single cylinder diesel engine. During endurance test; three fuel samples such as D100 (%diesel fuel as a baseline), B25 (waste cooking oil biodiesel 25% and 75% diesel fuel) and B25+LPG (liquefied petroleum gas and waste cooking oil biodiesel) respectively. At the end endurance test for each fuel samples, carbon deposit was analyzed on the fuel injector while using SEM and EDX techniques. However, an endurance test was carried out at constant rpm and constant load condition. From results, it was found that the injector tip showed higher deposition of carbon in case of B25 fuel followed by B25+LPG and DF respectively.

Keywords— *Injector deposit, Biodiesel, LPG, SEM, EDX*

1. INTRODUCTION

Carbon deposits defined as assorted mixtures made up of carbon ash, carbonaceous mixtures (soot) and oxygenated resinous organic substance that combine together as mixtures some of engine parts in the combustion chamber like the piston, intake and exhaust valves, cylinder head and injector tip are common parts where engine deposits regularly accumulate [1]-[3]. The ester lubricity additives do not affect the zinc levels of the fuel, even as the acid lubricity agent appeared to be implicated in the uptake of the zinc. The advanced diesel injection system is characterized by a higher temperature in the area of the injector tip that can lead to particular stubborn deposits on and around the injector tip [3]. the formation of deposition within holes of the injector or on the outside of the injector tip may have an adverse effect on overall system performance [4]. Therefore, it is likely that fuel stored in the injector tip is heated during the combustion process and expand during the expansion stroke [7]. It has reported that some biodiesel such as higher viscosity lower volatility [8]. The reactivity of unsaturated hydrocarbon chains can lead to injector coking and trumpet formation on the injectors, more carbon deposits, etc. after the engine has operated for a longer time period [9]. A comparative study of the effects of biodiesel and diesel fuel in two single-cylinder engines with the same injector specifications and fuel injection pump pistons was experimentally analyzed [10].

2. MATERIALS AND METHOD

The endurance test has been carried out for 60hours on each fuel samples. Initially, fuel properties have been tested at the ASTM standard. Which are given in Table.

Table 2.1: Biodiesel composition by volume and LPG

S. No.	Fuel sample	Composition by volume
1	DF	Diesel 100%
2	B25	Diesel 75% Biodiesel 25%
3	B25+LPG	Biodiesel 25% Liquefied petroleum gas

2.1 Endurance Test

For endurance test, the engine has been run on a constant load of 9.8 N-m and constant rpm 1300. At the first stage; the engine was run for 60 hours on diesel fuel. After completed the 60-hour duration fuel injector was replaced for deposition analysis. Before engine run on alternative fuel, the engine was run for 10 min on diesel fuel to warm up the engine that engine was run on constant load and constant rpm. The aim of this test is to determine the elemental deposition on the injector. Overall three injectors have been tested. Microscopic and visual inspection has been carried out on different locations of the nozzle. During the test, the losses in kinematic viscosity were also determined. Total 3 lubricant oil samples were collected from the engine. Each test sample was collected after 20 hours run. After completed the task of engine run on 60 hours, deposition of aromatics compound elements were analyzed. The elemental deposition of aromatic compounds deposited on the surface of the injector nozzle during the endurance test was examined by the microscopic test.

3. RESULTS AND DISCUSSIONS

3.1 CI engine injector deposit formation

In this part study of elemental depositions on CI, engine injector has been presented. Overall three injector have been discussed in this work. Each injector runs on different fuel such as diesel D100, B25, and biodiesel blend with liquefied petroleum gas (B25+LPG). In order to obtain results, continuous 60 hours run the engine on each fuel samples was carried out. After completion of 60 hours, the injector was disconnected from the cylinder head. The photograph has been taken for visual inspection as shown in Fig 3.2-3.6. From Figure 3.2-3.6 it has been observed that elemental depositions are formed around injector tip in several positions. In order to know about the elemental deposition, scanning electron microscopy and energy dispersive x-ray spectroscopy test has been carried out.

3.2 Injector Visual Inspection

The biodiesel is derived from vegetable, animal fats, and waste oils. It is very useful for improving the engine performance. Figure 3.2-3.6 shows the surface of the different injectors, running on the different fuel of samples. However, the injector at zero hours as shown **in figure 3.1**, that has been a new one injector used. In this circumstance, there is no any deposition to be analyzed. It is very difficult to compare the injector when deposition has been formed on the surface. It has been observed that diesel (D100) produced higher deposition injector surface as compared to diesel fuel (B25) and biodiesel blend with additive (B25+LPG)

3.3 Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray Spectroscopy (EDX) Analysis

Figure 3.1 represented the 60hrs run on diesel fuel (D100). After completing the 60hrs, the injector of each fuel sample was disconnected from the engine for scanning electron microscopy and energy dispersive x-ray spectroscopy analysis, deposition on the injector tip was due to that high temperature produces in the engine[30]. In this work, electron microscopic results were taken at a 100X magnification at a different location where the maximum deposition has been found.

A	**Injector Condition at 0Hr**	
B	**Injector Condition at 60Hr runs on Diesel (D100) fuel**	
C	**Injector Condition at 60Hr runs on Biodiesel blend (B25) fuel**	
D	**Injector Condition at 60Hr runs on B25+LPG fuel**	

Fig. 3.1: Different fuel injectors

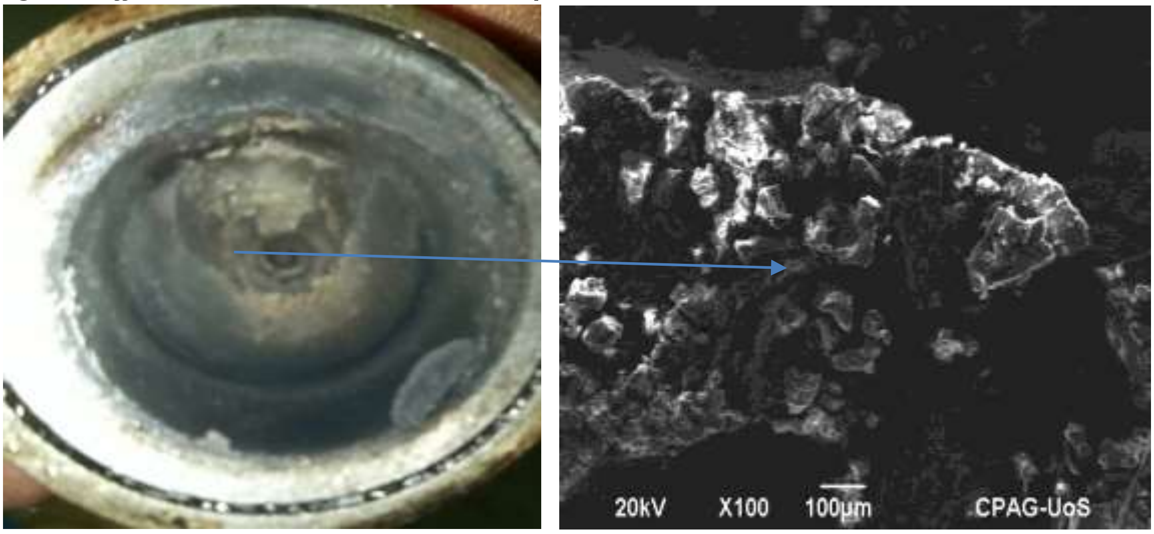

Figure 3.2 Injector condition at 60Hr runs on diesel (D100) fuel

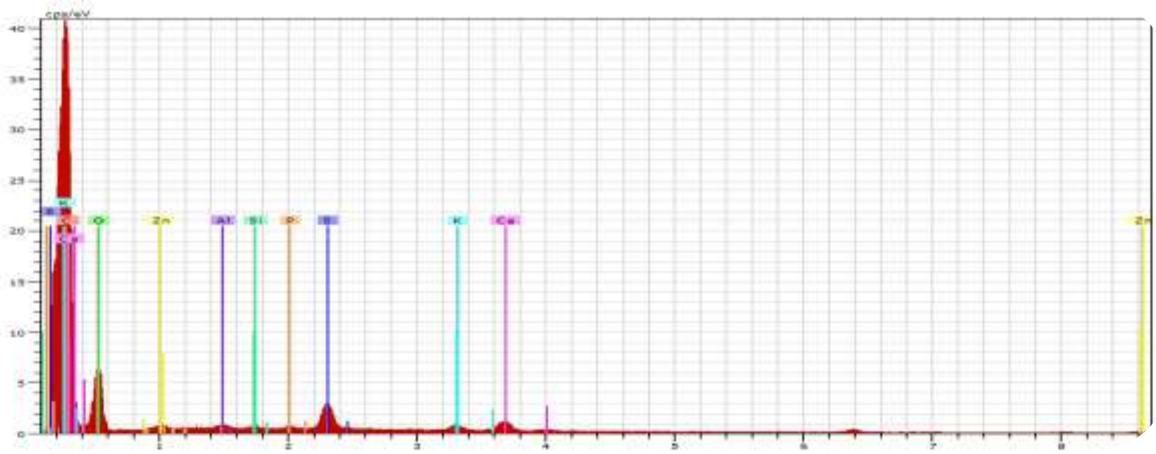

Fig. 3.3: Injector condition at 60Hr runs on diesel (D100) fuel

Table 3.1: Quantitative analysis of injector after 60 Hr runs on (D100) fuel

Element	C Norm wt%	C Atom wt%	C at%	Error%
Carbon K-series	56.42	65.42	64.45	17.3
Oxygen K-series	40.04	40.40	34.34	12.5
Sulfur K-series	1.44	1.44	0.62	0.1
Calcium K-series	0.97	0.97	0.33	0.1
Iron K-series	0.58	0.58	0.14	0.0
Zinc K-series	0.54	0.54	0.11	0.0
Total	100.00	100.00	100.00	

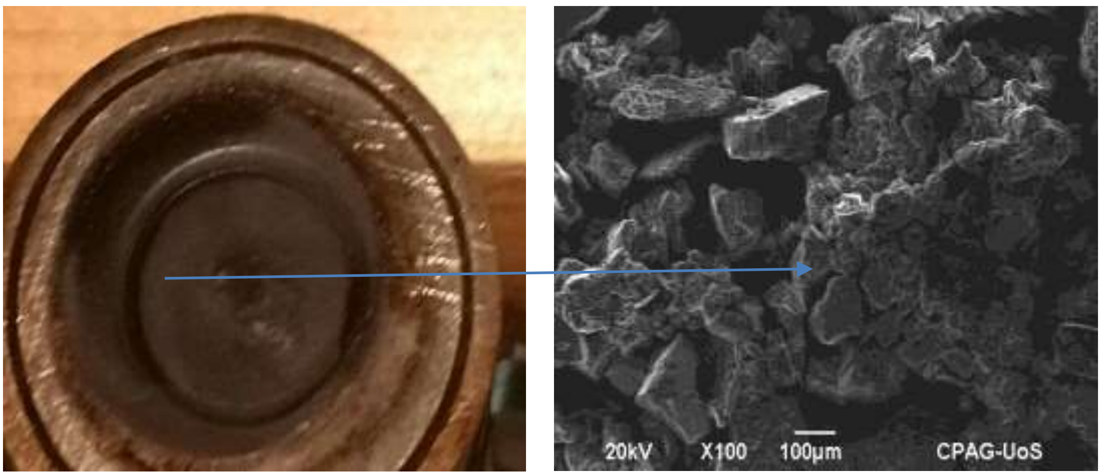

Fig. 3.4: Injector condition at 60 Hr runs on biodiesel blend (B25) fuel

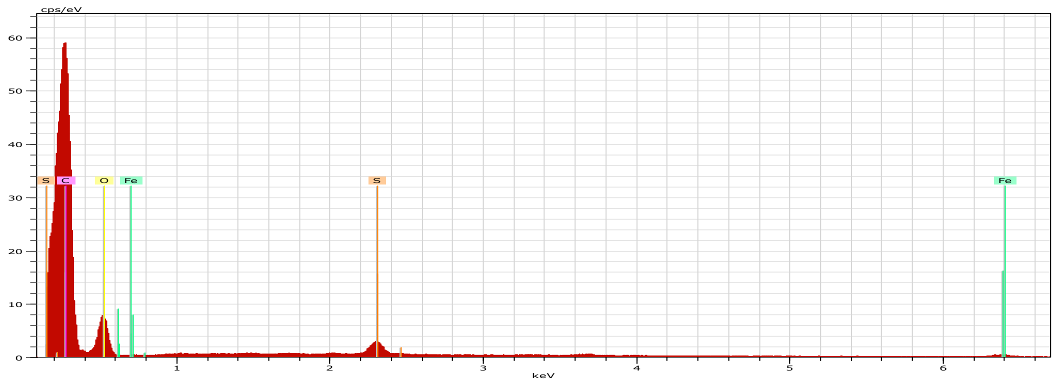

Fig. 3.5: Injector condition at 60Hr runs on diesel (D100) fuel

Table 3.2: Quantitative analysis of injector after 60 Hr Runs on (B25) Fuel

Element	C norm (wt%)	C Atom(wt%	At%	C Error %
Carbon K-series	60.13	69.13	67.34	18.4
Oxygen K-series	38.09	38.09	32.02	11.9
Sulfur K-series	1.16	1.16	0.49	0.1
Iron K-series	0.62	0.62	0.15	0.0
Total	100.00	100.00	100.00	

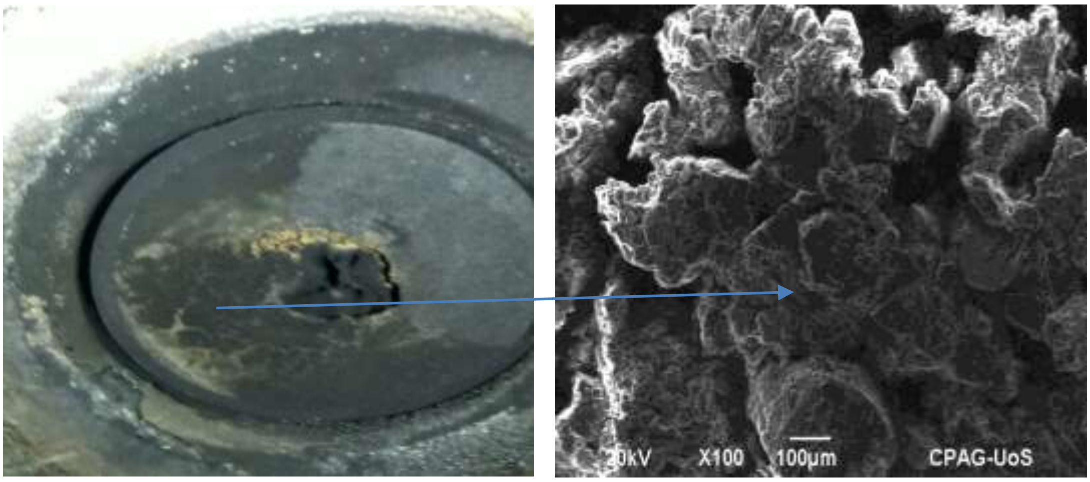

Fig. 3.6: Injector condition at 60Hr runs on biodiesel blend + LPG fuel

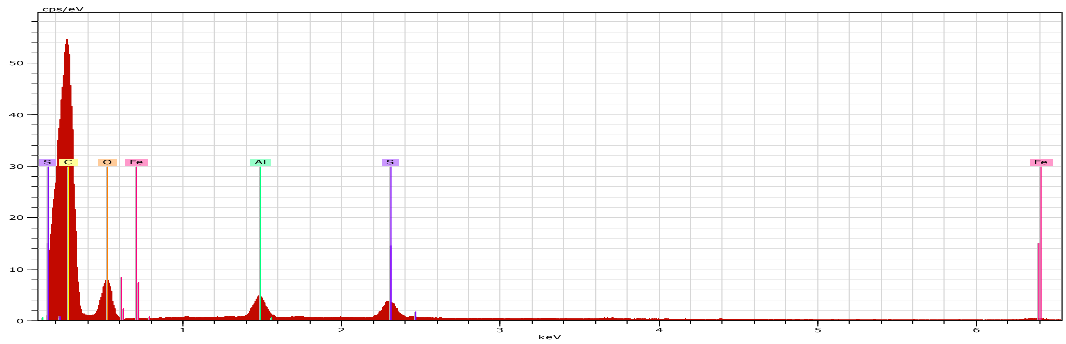

Fig. 3.7: Injector Condition at 60Hr runs on biodiesel blend + LPG Fuel

Table 3.3: Quantitative analysis of injector after 60Hr Runs on (B25+LPG) Fuel

Element	C norm (wt.%)	C Atom (wt.%)	(At.%)	%
Carbon K-series	57.94	57.95	65.90	17.8
Oxygen K-series	37.72	37.72	32.21	12.0
Aluminum K-series	2.01	2.01	1.02	0.1
Sulfur K-series	1.67	1.67	0.71	0.1
Iron K-series	0.65	0.65	0.16	0.0
Total	100.00	100.00	100.00	

4. RESULTS AND DISCUSSIONS

The engine has been run 60hours on different fuel samples. After the completed 60hours, scanning electron microscopy(SEM), Energy Dispersive X-ray spectroscopy test was carried out with different location of injector surface, however, results found that the deposition has occurred at the different locations of injectors. The compositions of an element like carbon and oxygen. Carbon generated by two methods one is splitting hydrocarbon into hydrogen and carbon and other is polymerization of hydrocarbon element.D100 produced 56% of carbon shown in the figure. 3.2 to 3.6 and B25 produced 61% of carbon and B25+LPG produced 57% of carbon respectively. Like oxygen element deposition was found D100 is 40.04%, B25 is 38.72%and B25+LPG is 37.72%. Another elements was foundD100 are sulphur 1.44%, Calcium 0.97%, Iron 0.58% and zinc o.54% like B25 are sulphur 1.16% and iron 0.62%. The higher distillation temperature leads to increase deposition formation on injector surface.

5. CONCLUSIONS

In this research work, an endurance test was carried out 60 hours of running on an engine at constant RPM and constant load. During endurance test, higher deposition of carbon and other aromatic compounds were investigated in B25.due to unsaturated double bond. Whereas D100 has fewer carbon depositions, instead of other aromatic compounds and B25+LPG higher carbon deposition as compared with D100. However, D100 has fewer carbon depositions and most efficient fuel for compression ignition engines

6. REFERENCES

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