Impact of Alcohol Blended Fuels on Engine Head Accumulation in SI Engine

A. M. Ansari[1], L. A. Memon[2], F. A. Solangi[3], A. A. Noonari[4], M. Zulfiqar[5], A. Rab[6]

[1,6] *Department of Technology, Faculty of Engineering Science and Technology (FEST), Hamdard University Karachi, Pakistan*
[2,3,5] *Department of Mechanical Engineering, Quaid-e-Awam University of Engineering Science and Technology Nawabshah Sindh, Pakistan*
[4]*Department of Environmental Sciences, Aror University of Art, Architecture, Design and Heritage, Rohri, Sukkur 65200, Pakistan*

[1]ali.murtaza4646@gmail.com

Abstract- Alcohol can serve as a renewable substitute for fossil fuels. The energy supply of a country has a large effect on its economic development. The energy is derived from fossil fuels that are non-renewable and adversely affect the environment. This study compares waste cooking oil and diesel fuel as a binary combination. Engine tests are performed under a continuous load at 1450 rpm. The impact of PF95E10 and PF95nBu5 on engine head deposit was investigated in this study when ethanol and n-butanol blend fuel was injected during the endurance test instead of base gasoline. When examining the study's results visually, it was noted that both gasoline samples showed some deposit accumulation on their engine head. Analysis using (SEM) and (EDX) revealed that the engine utilizing PF100 generated larger carbon deposits on and around the valve surface. Moreover, the PF95E5 and PF95nBu5 binary mixture can be utilized in a gasoline engine without modifications. The investigation of the experimental results shows percentage of carbon layer on engine head surfaces for PF, PF95E5, and PF95nBu5 is 41.67%, 43.42%, and 21.01%, respectively. During the experimental analysis, very little deposit development was seen for the fuel PF95nBu5.

Keywords- SI Engine; Ethanol, N-Butanol, Deposit Formation

I. INTRODUCTION

In a spark-ignition engine, ignition by a spark plug is the starting event for combustion. The gap needs to be big enough to consistently ignite the air-fuel mixture with a powerful spark, but not so big that misfire is caused by the ignition voltage need [1-2].

Manufacturers define a gap in practical engines that balances these considerations, usually between 0.6 and 1.1 mm in cars. The gap essentially determines the initial flame kernel's size; in a SI engine, combustion starts with a flame kernel that is roughly on the order of the spark gap distance [3].

Concerns over energy security and the growing cost of fossil fuels have increased in recent years. It is common knowledge that fossil fuels are utilized extensively in the automotive and energy sectors. The environment is harmed by greenhouse gas emissions that result from the widespread use of these fossil fuels [4]. About 25% of the greenhouse gas pollutants in the atmosphere come from transportation vehicles, making them one of the biggest sources of emissions [5-6]. This is due to the fact that vehicles running on unleaded gasoline (E0) have lower air quality and emissions [7].

However, in high pressure situations, an excessively large gap may make it difficult for the ignition system to generate a spark with enough energy and consistency, which could result in misfires or significant cycle-to-cycle fluctuation [8].

These gains are frequently ascribed to the longer spark discharge duration and faster, more thorough combustion resulting from a larger initial flame kernel. However, extremely large gaps have been associated with unfavourable consequences [9].

The literature contains a wealth of research findings regarding the formation of spark plug deposits while using biofuel and similar fuel blends. Renewable fuels derived from vegetable oil can provide strong engine performance in an emergency. Long-term usage of specific fuels can actually harm the engine, cause excessive carbon and lacquer deposits, and impair engine efficiency [10].

For three reasons, the spark plug gap is regarded as one of the crucial elements that needs to be correctly set before the plug is inserted within the engine: (1) A misfire could occur if the gap is too large because the electrical voltage might not be strong enough to arc across it. (2) A misfire could also occur if the spacing is too small because the spark might not ignite a "lean" air/fuel mixture. (3) A spark plug's voltage demand is closely correlated with gap size. Additionally, the electrode gap affected the early

development of a flame (kernel), which was crucial in dictating the flame's subsequent behaviours and, consequently, affected engine performance [11-12]. Gasoline engines benefit from the Atkinson cycle's distinct thermodynamic mechanism in a number of ways, which makes it a desirable choice for increasing fuel economy and lessening environmental impact. The Atkinson cycle's larger expansion ratio makes it possible to extract more energy from the combustion gases before they are released, which improves fuel economy, thermal efficiency, and lowers CO_2 emissions [13-16]. Further investigation into novel and intriguing alternative fuel mixtures for compression ignition (SI) engine applications is required due to the aforementioned difficulties [17].

The formation of engine head deposits in a SI petrol engine should be examined concerning the incorporation of ethanol and n-butanol (five percent by volume) as well as PF (95 percent by volume and ninety-five percent by volume) into regular petrol fuel. During a 120-hour endurance test, the engine head, engine performance, and emission levels will be compared using PF (petrol fuel), as well as the PF95E5 mix and PF95nBu5. The main aim of this work is to achieve this. This research aimed to establish the most effective ethanol and n-butanol blend fuel and petrol binary mixture.

Nomenclature	
PF100	Petrol 100%
PF95E5	Petrol 95%+Ethanol 5%
PF95nBu5	Petrol 95%+Butanol 5%
HD	Head Deposit
SI	Spark Ignition Engine
SP	Spark Plug
PG	Petrol Engine

II. Material and Methods

2.1. Experimental Work

The engine under study is located in the thermodynamics lab of QUEST University at thermodynamics laboratory Nawabshah. The key fuel characteristics are listed in Table 1. The experimental setup. The physiochemical characteristics of ethanol and n-butanol, or pure gasoline, and engine parameters are shown in Tables 1 and 2.

The engine was first powered by PF100 in order to set the baseline parameters, and then it was powered by blend fuels. To find the mean values, each test was run three times. The selected test fuels are PF95E5 and PF95nBu5. During the blending process, a great deal of work is required to ensure homogeneity and consistency among the samples. The engine was run for five minutes to stabilize it before data gathering began.

It serves as a test bed for a P8160 single-cylinder engine. This 1.0 kW single-cylinder test engine was outstanding. Eight heating elements were placed at each corner of a constant volume combustion tank that had two circular quartz observation windows with a diameter of 100 mm. In order to keep an eye on the heating, components mentioned and enable ongoing monitoring of the fuel-air mixture state inside the chamber, the vessel's temperature was modulated using closed loop control. The spark plug for the ignition process was placed in the middle of the vessel's top cover, and a pressure release valve that operated at 7 bar was installed on the vessel's side for safety. The apparatus's general configuration and test rig are depicted in Fig 1 and 2.

Table .1: Characterization of Alcohol Blend.

Properties	**E5**	**nBu5**
Research Octane Number	108-129	96-98
Viscosity (Pas) at 20 ◦C	0.789	0.808
	26.8	33.1

Table.2: Engine Specification

Model	**4- Stroke, SI**
Maximum Torque at 2500rpm	18.5 Nm
Briggs & Stratton OHV	P8160
Maximum Power at 3600rpm	9.5 BHP (7.1 kW)
Engine type	Single Cylinder
Number of Stroke	4
Swept Volume	0.304mm^3
Fuel	Petrol
Cooling System	Air Cooled

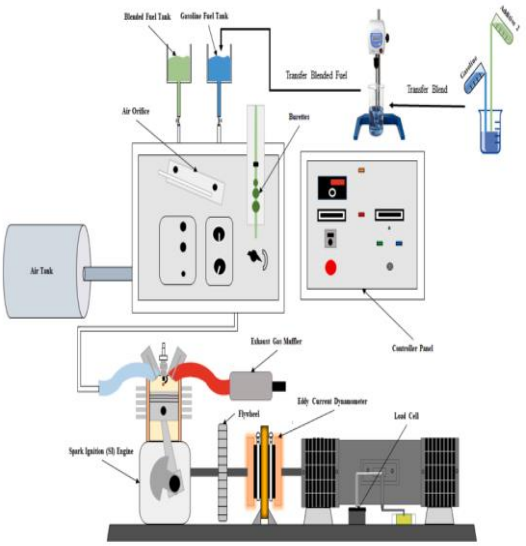


Figure.1 Schematic Diagram Test Rig

2.2. Preparation of Fuels

PF100	Petrol 100%
PF95E5	Petrol 95% + Ethanol 5%
PF90nBu10	Petrol 95% + n-butanol 5 %



Figure. 2 Engine Test Rig

III. Results and Discussion

3.1 Engine Head

The engine head was recorded using gasoline-ethanol and gasoline-butanol during a 120-hour endurance test on baseline fuel, as shown in Figure 3. looking at the surface of the head.

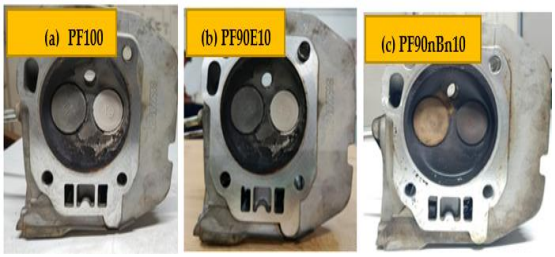


Figure. 3 View of Head Accumulation Consuming Blend Fuels.

As seen in Fig. 3, the accumulation of de-posits was visible in the liners of both fuel samples following varying running hours. In both cases, deposits were found near the rings, channels, and piston head. However, compared to the PF95nBn5 mix gasoline, the smoke deposit was more noticeable in the PF95E5 engine. This suggests that even a small amount of n-butanol in the mixture greatly enhances the combustion process, resulting in the full oxidation of the fuel and lubricating oil vapor. Nevertheless, the head surface of the PF95E5 engine was dirtier than that of the PF100 and PF95nBu5 engines. The PF100 and PF95E5-run engine head surfaces showed white, greasy deposits, while the PF95nBu5-run engine head surfaces showed dry deposits.

3.2. SEM and EDX

after every test fuel was put through a 120-hour durability test. In order to examine the deposits that had developed on each engine head, the engine was then partially disassembled. At a magnification of 25, Figure 4 shows SEM micrographs of deposits on each of the fuels that were assessed. More heat is known to be produced at and around the injector tip in complex gasoline injection systems, which can lead to deposits that are particularly challenging to remove [18-19].

Diagram Following the accomplishment of the long-term 120-hour durability test on gasoline, gasoline-ethanol and the gasoline-butanol blend, the engine was partially disassembled and the accumulations development on each engine analysed.

However, their relative carbon (C) contents are 41.67% and 43.42%. The amounts of carbon (21.01%) and oxygen (6.86) on the PF90nBu10-fueled valves' surfaces are relatively. This implies a lower concentration of carbon in the accumulation layer [19-20]. However, figure 4 (f) shows that the basic metal iron (Fe) content of all test fuels is 0.79, 2.44, and 53.74, suggesting that binary blends have lower iron levels than the others. Carbon deposition is comparatively lower in PF90nBu10 mix fuels than in PF100 blended fuels, as was previously shown. The PF90E10 binary blend fuel deposition exhibits phases that resemble grains [21]. This could be due to the presence of different carbon and oxygenated molecules.

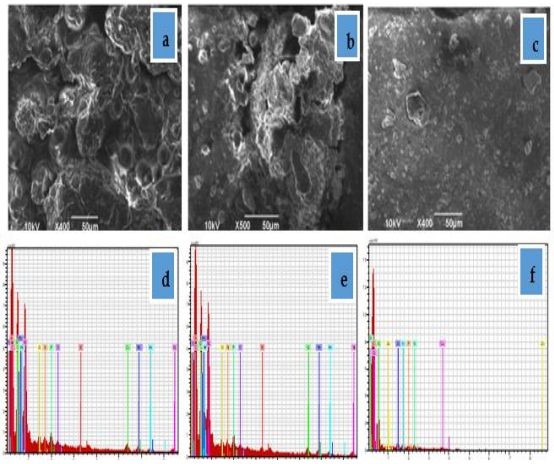


Figure.4 SEM and EDX Baseline Using Alcohols Fuels

IV. Conclusion

This study focused on the effects of ethanol and n-butanol blends on engine wear and head deposits during a 120-hour period using PF as the baseline fuel. Even though the percentages of blends differed for the long-term endurance test for safe operations and investigative examination, the following results were obtained:

- A visual examination revealed some deposit

accumulation in the engine head when the engine was operating on either fuel (PF100, PF95E5, or PF95nBu5). Nevertheless, it was discovered that the engine head employing PF95E5 was dirtier than the head using PF and PF95nBu5.

- Dry deposits were seen on the engine head when using PF95nBu5, as opposed to oily, greasy, or white deposits that were seen when using PF100 and PF95E5.
- After the endurance test, SEM and EDS examination revealed that the engine head surface deposits of PF100 and PF95nBu5 were significantly lower than those of the PF95E5 blend. The carbon layer was unevenly thick due to the deposition.

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