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Engine Performance and Emission Evaluation of Gasoline-Ethanol Fuel Blend in SI Engines Under Various Conditions of Load and Speed

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Abstract

Ethanol fuel is considered a renewable energy source with a lower global warming potential than gasoline. The purpose of this paper is to analyze the emissions and performance of gasoline-ethanol blends in SI engines under various conditions. A computerized 4s, 1cyl, VCR spark ignition engine is used for the tests to measure the performance of Gasoline-Ethanol (GE) blends in particular E-10 (10% ethanol, 90% gasoline). For measuring exhaust emissions as well as performance, regular gasoline fuel is used for the additional tests. Engine performance using ethanol-gasoline blended fuel has been evaluated at different working conditions: 1200–1800 rpm, AFR 0.9, STs 300, CR10:1. When vehicles running on ethanol-gasoline blend indicated a decrease in the amounts of HC, NOx, and CO exhaust gases while 3.9% increase in CO_2 emissions as compared to unleaded gasoline fuel. Furthermore, it has been shown that the brake power, torque, specific fuel consumption increases when a Gasoline-Ethanol (GE) blend is used over regular gasoline fuel.

Keywords: *Blend, Emission, Ethanol, Gasoline, SI engine, Performance*

1.0 Introduction

Fossil fuel consumption would increase engine exhaust emissions making it important to develop this in the future. In this world, there are many alternative fuels. Because it is produced from biomass through plant fermentation and is referred to as bioethanol, ethanol is one of the fuels that can be used in India. Ethanol, as a biofuel with characteristics comparable to gasoline, can be utilized to substitute or blend for regular gasoline. Because of its regenerative as well as biodegradable features ethanol fuel is increasingly being used as an alternative energy source. In recent years, many countries throughout the world have pushed for the use of gasoline that contains 3-10% ethanol from biomass[1]. Fuel additives can reduce emissions while also improving engine performance and fuel efficiency. However, the potential benefits of using these fuels, such as less pollution and increased energy security, make them a viable choice for sustainable development. However, there are still issues that need to be overcome, like fuel compatibility, engine durability, and fuel availability, before alcoholic fuels may

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be used in SI engines[2]. Alcohols, which have about 108 high octane numbers, are more resistant to knocking or detonation during combustion, which results in smoother engine operation. Since spark-ignition engines tend to run at higher temperatures, their NOx emissions may also be higher. Alcohol use, however, may reduce these emissions by dropping the temperature of the charge blends injected into the cylinder[3]. Large amounts of greenhouse gases, which have a significant impact on global climate change, are known to be produced by fossil fuels. To decrease GHG emissions and dependence on fossil fuels, researchers are investigating biofuel with oxygen content as a feasible substitute[4]. An increasing percentage of humankind has turned to biofuel as an alternative to conventional fossil fuels. It can be combined with gasoline at a normal blending ratio of 10% in a variety of applications. The Indian government has stated that bioethanol will be added to gasoline at a rate of 20% till 2025, demonstrating an increasing focus on biofuels as a source of alternative energy[5]. The outcomes of this research provide insight into how various ethanol mixes affect emissions, fuel consumption, and performance which can help spark ignition engines to become more effective and ecofriendly. A small amount of alcohol added to the gasoline mixture can improve engine efficiency and brake power while reducing hydrocarbons and Greenhouse Gas Emissions (GHG). However, it can also increase both CO_2 and NOx exhaust emissions[6]. For further investigation as well as development in this area, it is essential to understand how ethanol-premium gasoline fuel blends work in multi-cylinder SI engines under various operating conditions. An enhancement of engine efficiency and the research of new environmentally friendly fuel sources may benefit from this knowledge. With advantages including fewer pollutants and a higher-octane rating, ethanol-premium fuel blends present a practical solution for conventional gasoline[7]. Suresh *et al.*[8] assessed from experimental outcomes, which adding 10% ethanol with gasoline fuel enhances Compression Ratio (CR), which in turn increases BTE as well as BP by 7% and 4.5%, respectively. Ethanol has the significant advantage of reducing cycle-to-cycle variations in HC emissions. An SI engine that operates on gasoline and ethanol can achieve much better performance and reduced emissions by using a high CR and lean-burn operation. Gupta *et al*[9]. In this study, employing gasoline blended with ethanol as a flex-fuel mixture in a motorcycle led to higher fuel efficiency and a slight increase in brake power output with decreased CO_2 and HC emissions. These findings can help to optimize the environmental as well as performance factors of using ethanol blends in motorcycle engines for low-load conditions. Kumbhar and Khot[10] reported the experiments using different STs of 18, 15, 21, 24 as well as 30 BTDC, both with and without the partial inclusion of n-pentane, and fuel types E20, E0, E40, and E60. Pollutants including NOx, CO, and HC decrease when the ethanol blend rises in the range between E0 and E60. However, the exhaust emission parameters showed unpredictable trends at varying Spark Timings (STs). Exhaust gas emissions were shown to be reduced when gasoline was mixed with 10% n-pentane. Without requiring any modifications to the engine, the E-20 blend with 24 BTDC offered the best optimistic outcomes out of all the fuel mixtures. Verma *et al.*[11] paper presented blending percentage enhanced the lesser engine performance and outcomes of the study observed that F-2 blends, or sample mixes containing less than 1 percentage Ethanol (E), worked rather well and could eventually replace the existing pure Gasoline (G). Mohammed *et al.*[12] in this paper effects of ethanol fuel blended into gasoline on emissions, power, and efficiency were evaluated as well as analyzed by using a 1-cyl, 4s, SI engine. The power, BTHE, and BSFC all improved as the ethanol percentage ratio increased, based on outcomes. On the opposite side, ethanol fuel was found to reduce volumetric efficiency. Moreover, increasing Ethanol (E) fuel reduces hazardous exhaust gases. Fewer emissions are seen accompanied by higher ethanol levels. Köten *et al.*[13] presented findings indicating that raising the quantity of ethanol leads to higher nitrogen oxide emissions. 3-way catalysts and similar after-treatment methods may still be used to regulate total HC and CO emissions although they have reduced. Based on the outcomes, increasing ethanol level results in a modest rise in indicated engine power while decreasing ISEC values under stoichiometric conditions. Efemwenkiekie *et al.*[14] based on experimental results, under full load conditions, gasoline mixed with local ethanol improves brake torque, BP, and BTHE while lowering SFC. Among the fuel blends analyzed, E3 showed the highest engine performance parameters when operating at full load. Chansauria *et al.*[15] in this study, the engine's overall BTHE, HRR, cylinder gas pressure, and volumetric efficiency (Vol. Eff) are all improved by the mixture's percentage of Ethanol (E). It also increases the Critical Ratio (CR), which is needed for ignition to occur. Reduced carbon dioxide emissions result from the addition of ethanol fuel to gasoline, which increases the concentration of carbon dioxide (CO_2) in engine exhaust. The presence of Ethanol (E) in gas emissions minimizes the percentage ratio of NOx. Thakur *et al.*[16] the research presented in this paper showed that engine torque and Brake Power (BP) were increased by ethanol blends with smaller percentages. BSFC enhanced along with the increase in ethanol fuel concentration. By varying CR and operating the engine at different speeds, the SI engine's performance measurements were similarly impacted. Using an ethanol-gasoline blend resulted in a slightly higher Break Thermal Efficiency (BTE). The ethanol fuel blends with higher oxygen and Octane Numbers (ON) ignited more efficiently, which slightly raised power as well as torque. Singh *et al*[17]. Blends containing Ethanol (E) decreased the BSFC at all speeds when the throttle was fully opened. Blends of E20 reduced CO and HC emissions by 65% and 38%, respectively, at rated power conditions but requiring twice as much nitrogen oxide (NOx). Across all test fuels, the IMEP and engine's maximum peak pressure and boosted with speed; the ethanol fuel blends only slightly increased these values. As ethanol is blended into gasoline, it enhances combustion, which slightly increases engine performance and significantly lowers exhaust gas emissions. Phuangwongtrakul *et al*[18]. test outcomes observed that Brake Torque (BT) o/p can be increased, particularly at low speeds by using a proper Gasoline-Ethanol (G+E) blending ratio. When employing E-40 and E-50 fuels and running the engine at 58-73 percent of wide-open throttle with 2000-2500 rpm, to get the highest BTHE. Elfasakhany[19] in this paper outcomes demonstrated moderate exhaust pollutant levels between standard gasoline fuel and ternary blends (G+E+M) while they also indicated minimized UHC and CO concentrations related to the basic Gasoline (G). As the quantity of Ethanol (E) as well as Methanol (M) in the fuel mixtures increased CO_2 increased as well. Combinations of Gasoline (G) and Ethanol (E) offer the highest volumetric efficiency (Vol.Eff.), torque, and BP. Conversely, of all these test fuels, gasoline fuel has the least BT, BP, and Vol.Eff. Iliev[20] the outcomes revealed that as gasoline-alcohol mixtures have been employed over standard gasoline fuel, BSFC increased while BP reduced. As the fuel blend percentage boosts to 30% M30 /E30, NOx emissions drastically rise while the level of carbon dioxide as well as hydrocarbons declines. Balki *et al.*[21] discussed while compared to unleaded Gasoline (G), the outcomes showed that the use of Ethanol (E) as well as Methanol (M) raised the BSFC, BTE, CGP, and BMEP for all CRs. Pure methanol as well as ethanol provided less exhaust emissions than regular gasoline at all compression ratios. Canakci *et al.*[22] in this paper exhaust emissions, such as nitrogen oxides, UHC, carbon dioxide, and CO, declined for all output powers at a speed of 80 kilometers per hour as the engine was operated on gasoline and Methanol (M) or Ethanol (E) blends, based on test outcomes. As the vehicle reached 100 kilometers per hour, the emissions of fuel mixtures, particularly for 15-kilowatt wheel power, revealed more complicated trends. Additionally, results observed that, in comparison to the case of unleaded Gasoline (G), the A/F equivalence ratio rose as the amounts of both Ethanol (E) as well as Methanol (M) in fuel mixtures increased.

It is clear from the reviewed literature that adding ethanol to gasoline enhances its antiknock properties, allowing gasoline engines to operate at higher compression ratios. However, comparatively limited research has focused on predicting and validating how a high Compression Ratio (CR) affects engine emissions as well as performance analysis of SI engines under various conditions when using blends of gasoline and ethanol. The analysis of the effect of adding ethanol to gasoline at a higher CR for exhaust emissions and performance at various conditions is the novel aspect of this work. Current research addresses this gap by focusing on the gasoline-ethanol blend and whether it is compatible with existing vehicles or engines. The main aim of the current study is to identify the best gasoline-to-ethanol blends from the perspective of both performance and emissions. An experimental method is discussed in the next sections, and the work ends with a discussion of the results and a summary of conclusions.

2.0 Experimental Analysis

The study aims to assess the performance and emissions of a gasoline and ethanol blend in SI engines under different operating conditions. In the current research work, the experimental tests are conducted at STs 300, AFR 0.9, and CR 10:1 with different speeds of engine during 1200 to 1800 revolutions per minute for 100% gasoline and gasoline-ethanol fuel mixture. The next part covers particulars of fuel preparation (100% gasoline), engine setup, and experimental procedures.

2.1 Fuel Preparation

A fuel blend of ethanol with gasoline was employed in the experiment. A gasoline-ethanol mixture was made in Apex Innovations Pvt. Ltd. (AIPL) research lab in Sangali (Maharashtra state), India. We used "UN-1170 Ethanol" for this experiment, which was obtained from Impression Chemicals Enterprises (ICE), the dealer (Sangali). To ensure fuel uniformity properly agitate the cocktail after adding 5 milliliters of water blend into gasoline to extract the Ethanol (E) from the gasoline before starting the experiment. After the mixture is left for five to ten minutes, phase transition takes place when sufficient liquid fouls gasoline which is combined with ethanol. This leads ethanol to bond itself with molecules of water and fall on the bottom, disposing of the storage tank in 2 different stages, one that is made up merely of gasoline and the other containing an ethanol-water mixture. Gasoline is blended with ethanol to obtain blends that are 90% gasoline and 10% ethanol by volume; this composition is known as E10. Table 1 shows details of fuel properties. To obtain the best possible outcomes during tests, the engine was working at 1800 revolutions per minute with full throttle on a Gasoline-Ethanol (GE) blend between 1200 and 1800 rpm, for CR 10:1 experimental study result will be graphically compared. Using an "AIRREX" automotive emission analyzer, all trials involving CR, A/F ratio, STs, and ethanol-gasoline blend as well as exhaust gas emissions are validated and analyzed.

2.2 Experimental Setup and Procedures

Engine configuration consists of a 4s, 1cyl, Kirloskar gasoline engine with 4.5 kW (TV1) and VCR as shown in Figure 1. Table 2 shows engine specifications in detail. The Electronic Control Unit (ECU), digital manometer, burette and stopwatch, Exhaust Gas Analyzer (EGA), gasoline engine test rig, and chrome aluminum (K-Type) are among the equipment used for the specified work.

Table 1. Details of fuel properties[21].

Property	Gasoline	Ethanol
Oxygen (%Wt)	----	34.73
RON/MON	95 / 85	108.6/89.7
Auto-ignition temperature (^{0}C)	228 - 470	363
Boiling point (^{0}C)	27 - 225	78.3
Heat of vaporization (kJ/kg)	349	923
Chemical formula	----	C2H5OH
Density (g/cm3 at 20 ^{0}C)	0.72 -0.76	0.790
Latent heating value (kJ/kg)	44,300	26,900
Stoichiometric AFR	14.6	9.0
Adiabatic flame temperature (^{0}C)	2002	1920
Molar C/H ratio	0.44 to 0.50	0.33
Flammable limits (%volume)	1.4 - 7.6	3.5-15
Stoichiometric flame speed (m/s)	0.34	0.41

Table 2. Details of engine specifications (Apex Innovations Pvt. Ltd.)

Details	Items
Model	TV 1
Manufacturer	M/S Kirloskar Oil Engines Ltd.
Ignition	Spark Ignition
Cycle	4 Strokes
Rated Power	4.5kW @ 1800 rpm
Connecting rod	234mm
Compression ratio	10:1
Injection timing	359^0 BTDC
Injection pressure	3 bars
Bore/Stroke	87.5 /110 mm
No. of Cylinders	1 Cylinder
Type of Cooling	Water Cooled
Cubic Capacity	661 cm^3

Figure 1. Computerized 4s, 1cyl, VCR Petrol engine setup Source: Apex Innovations. (Combustion research lab).

At varying loads, the Internal Combustion Engine (ICE) was connected to an Eddy Current Dynamometer (ECD). The test engine's CR was set to 10:1. Vital instruments for measuring Crank Angle (CA) as well as cylinder pressure were set up in the test rig. Signals for P-V and P- P-diagrams were interfaced with data recorders and computer systems. The computer was connected to fuel flow, airflow, Temperatures (T), and engine load readings. a panel box with a gasoline fuel assessing system, fuel tanks, an air box, for the blend tests, as well as a U-tube manometer.

The system included transmitters used to monitor fuel and airflow. Cooling water rotameters and calorimeters were used to measure the flow of water. At a constant speed of 1800 rpm, experimental ethanol-gasoline blends were evaluated under a variety of load conditions, ranging from 0 to 24 kg. Tests evaluated engine performance using a variety of parameters, such as heat balance, mechanical efficiency, BSFC, BP, BT, FP, BMEP, FMEP, BTHE, and IP. Engine exhaust gases including CO, NOx, O_2, HC, and CO_2, are analyzed by using the "AIRREX" Exhaust Gas Analyzer (EGA). Table 3 displays details about the exhaust gas analyzer. Online engine performance evaluation is done using the LabVIEW-based "engine soft" software package. An in-cylinder pressure sensor was fitted to a test engine to collect pressure data. Cylinder pressure readings between -3600 and +3600 CA were recorded using a National Instruments Data Acquisition (NDA) device for each crank angle. The temperature of exhaust gases is measured using K-type thermocouples.

As illustrated in Figure 1, the test rig operates on Gasoline-Ethanol (GE) fuel combinations and is driven by a computerized 1cyl, 4s VCR Kirloskar 4.5 kW (TV1) SI engine without requiring any engine modifications. Schematic arrangement of engine setup is shown in Figure 2.

In this study, the engine speed with 30^0 Spark Timings (STs) is maintained between 1200 and 1800 rpm for a CR of 10:1, and the A/F ratio is kept at 0.9 at all operating conditions.

All emission and performance measurements are evaluated 4 times and the following test procedures are conducted on an SI engine with E0 and E10. (i) Before switching on the engine, fill the fuel tank with the tested fuel. (ii) For cooling purposes, the water pump supply is commencing. Rotameters should be set to the designated water level to obtain the required mass flow rate of liquid. (iii) Turn on the loading as well as speed indicators. (iv) The fuel flow is opened using the PFI controller. (v) Connect a computer installing the LabVIEW software (Engine soft) to the engine for analyzing the data. (vi) Before achieving a steady condition, the engine was started with no load and set to idle for 5 minutes. (vii) To boost the air supply rate, turn the throttle very slightly. (viii) To change the

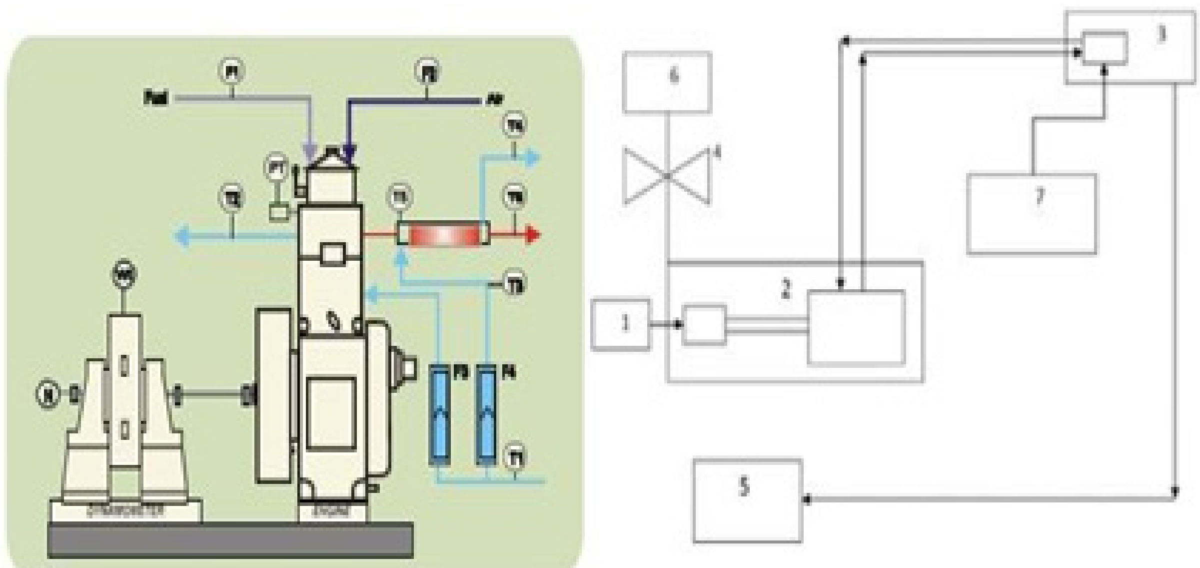

Figure 2. Schematic arrangement of engine setup, **(a)** Diagram **(b)** Line diagram.

1. Eddy Current loading Dynamometer, 2. 1- cyl, 4s gasoline engines and Alternators, 3. Exhaust- gas Recirculation Systems, 4. Control valve (CV), 5. Smoke meter (SM) *and* Exhaust Gas Analyzer, 6. Fuel/oil Tank, 7. Air drum/ cylinder.

Where,
Jacket cooling water inlet temperature -T1 ^{0}C
Jacket cooling water outlet temperature -T2 ^{0}C
Calorimeter cooling water inlet temperature -T3 ^{0}C
Calorimeter cooling water outlet temperature -T4 ^{0}C
Exhaust Gas Temperature (EGT), before the calorimeter -T5 ^{0}C
Exhaust Gas Temperature (EGT), after the calorimeter-T6 ^{0}C
Flow rate of fuel - F1 Kg/s
Flow rate of air -F2Kg/s
Cooling water engine jacket flow rate -F3 Kg/s
Cooling water calorimeter flow rate -F4 Kg/s
Reading of Load cell -Wt

Table 3. Technical details of Exhaust gas analyzer[18].

Model	Infralyt CL
Measuring principle	NDIR
Measuring range	
O_2	0-25 vol.%
UHC	0-2000 ppm
CO_2	0-20 vol.%
CO	0-10 vol.%
Lambda	0-9999
r/min	400-9999
Temp.	0-130 ^{0}C
Exhaust gas temp. range	range 0-600 ^{0}C

load, slowly and carefully turn the load knob. (ix) Check varying each throttle setting and load adjustment to get the required steady speed. (x) Air consumption is measured via the connected software programs. (xi) The fuel consumption level for 10 cc is recorded using a stopwatch and a stand-alone box fuel controller. (xii) The required A/F ratio is set using the software's throttle and fuel map. (xiii) Before getting the results, the engine runs for 10 minutes to reach stability for each test condition. (xiv) Save the obtained data in the chosen folder. (xv) Get records under different loading conditions as well. Lastly, with the throttle and load knobs at zero, use the software program to stop the engine. Then shut down the supply of fuel. Repeat the same procedure for gasoline (G) and gasoline-ethanol (GE) blends. (xvi) The airrex exhaust emission analyzer HG-540 is employed to quantify emissions including HC, O2, CO, CO_2, and NOx.

3.0 Result and Discussion

For engine performance as well as emissions assessment a 1-cylinder, 4-stroke, VCR gasoline engine with Gasoline-Methanol (GE) blend is used. This experiment employs pure gasoline as well as Gasoline-Ethanol (GE) fuel mixtures at speeds ranging from 1200 to 1800 rpm with an SI engine. Both engine exhaust emissions, as well as performance analysis, were evaluated by using regular gasoline fuel and blends of ethanol and gasoline at various operating conditions at constant CR =10:1, an A/F ratio = 0.9, and an STs 30 ^{0}. The following section shows the impact of gasoline-blended ethanol in percentages ranging from 0 -10% on performance measurements such as BP, BT, and BSFC as compared to rpm and emissions like NOx, CO, CO_2, and HC.

3.1 Engine Performance Characteristics

3.1.1 Brake Torque

Figure 3 represents torque changes in speed for E10 (10 % ethanol + 90% gasoline) blends and E0 (100% gasoline) when speed increased, it was noted that brake torque improved proportionally for all test fuels. As compared Gasoline-Ethanol (GE) blends to pure Gasoline (G), a torque increase was observed. Furthermore, at low engine speeds, E10 obtained slightly higher Brake Torque (BT) than E0.

3.1.2 Brake Power

The graph for BP against various speeds in rpm for blends of gasoline-ethanol (E10) and regular gasoline (E0) is shown in Figure 4. BP of each fuel enhances with rising speed. At higher speeds, employing E10 blends will provide

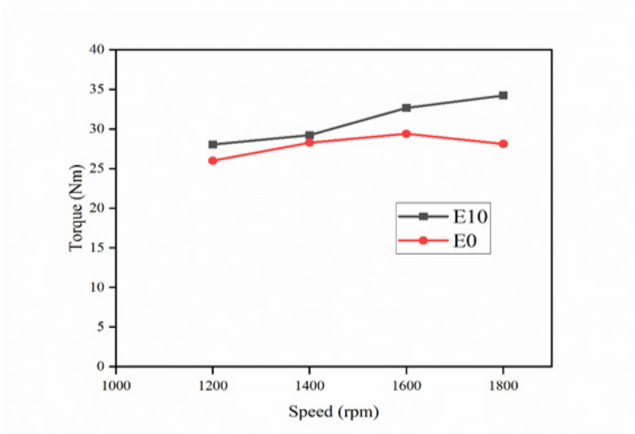

Figure 3. Variation in brake torque with speed.

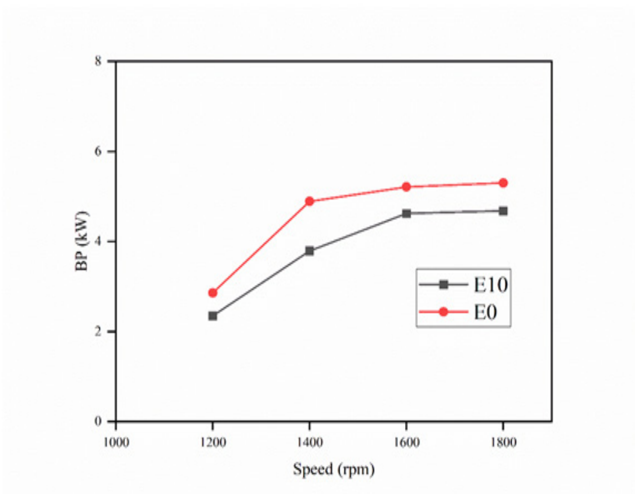

Figure 4. Variation in brake power with speed.

nearly the same BP as pure gasoline, as represented by the graphs' trends. Moreover, because ethanol has a higher-Octane Number (ON) than gasoline, it performs better. An improvement of 10% in the gasoline with ethanol content results in an increase in engine power. Unleaded gasoline and other blended fuels follow the same trend.

3.1.3 Brake Specific Fuel Consumption

Figure 5 demonstrates trends of the graph of SFC with respective speeds towards E10 and E0. For each test fuel SFC is minimum at 1800 rpm. It starts decreasing as rising engine speed. More oxygen improves combustion efficiency, which eventually lowers SFC. For blend ratios

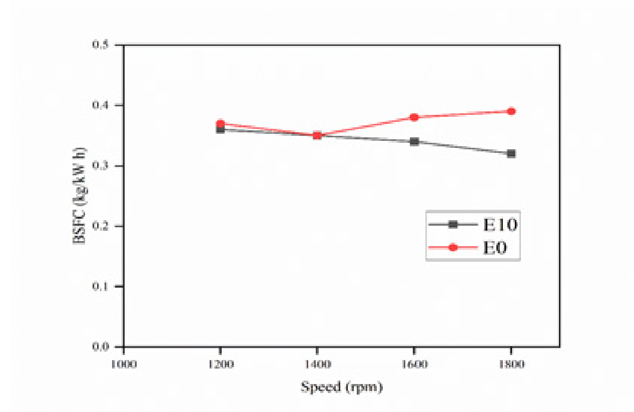

Figure 5. Variation in brake-specific fuel consumption with speed.

of less than 10%, it was found that BSFC depends more on engine speed than ethanol contents. The use of ethanol-gasoline fuel mixtures has also led to a minimal increase in fuel consumption as compared with unleaded gasoline. As volumetric efficiency increases, combustion efficiency improves, and the SFC drops in response.

3.2 Engine Emissions Characteristics

3.2.1 Carbon Monoxide

Figure 6 represents the change in CO with speed. As compared to pure gasoline (E0), the percentage of CO in E10 blends decreases with increasing speed. It indicates that there is a decrease in CO concentration in the C.R.

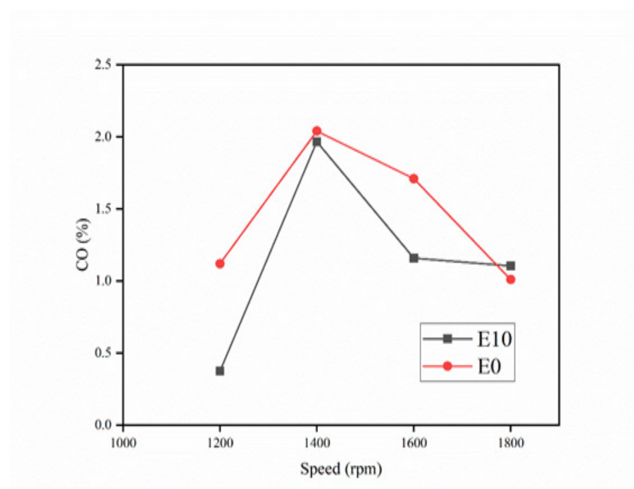

Figure 6. Variation in Carbon monoxide with speed.

of 10:1. The graph shows that the CO level decreased as the ethanol percentage increased. The graph shows that CO emissions reduce as the ethanol content in the mixture varies. Improved timing of ignition leads to the achievement of the combustion phase.

3.2.2 Carbon Dioxide

Effects of the E0 and E10 gasoline mixtures on CO_2 emissions at various engine speeds are represented in Figure 7. Carbon dioxide (CO_2) emissions increase with rising engine speed. At 1800 rpm, the CO_2 emissions would range from low to moderate to higher. Gasoline-

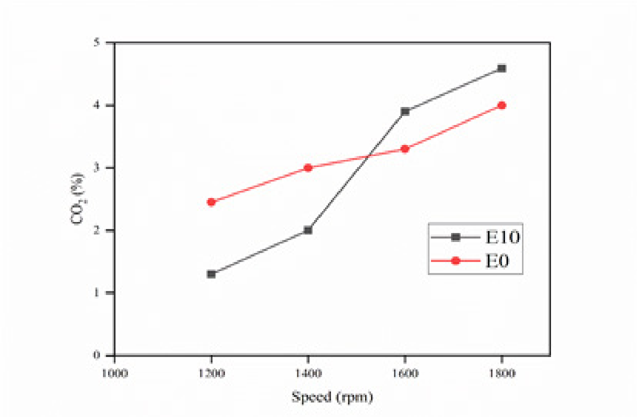

Figure 7. Variation in carbon dioxide with speed.

Ethanol (GE) blends have lower carbon levels than regular Gasoline (G). In addition, the higher oxygen ratio in ethanol contributes to increased CO_2 emissions from ethanol-gasoline blends due to improved combustion efficiency.

3.2.3 Hydrocarbon

Figure 8 indicates graphs of change in HC emission with engine speed. It has been demonstrated that adding ethanol considerably reduces the amount of HC emissions produced in comparison to gasoline fuel. About the graph, at a compression ratio of CR 10 with a rise in the ethanol percentage in gasoline, HC emissions drop.

For E10, it has been shown that the HC level drops at 1800 rpm engine speed. The diagram clearly shows that as speed increased, HC emissions decreased. Hydrocarbon emissions show a decreasing inclination with increasing

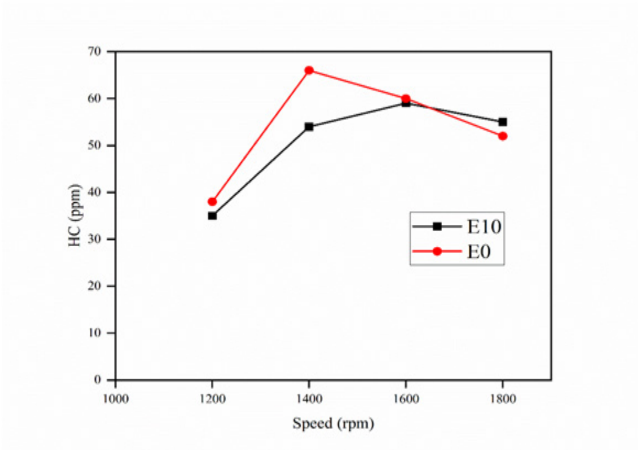

Figure 8. Variation in Hydrocarbon with speed.

loading and complete combustion of fuel, which is even better for oxygenated fuel. As ignition timings increase the amount of ethanol increases, the graph indicates that the emission of hydrocarbons decreases.

3.2.3 Nitrogen Oxide (NOx)

Graphs illustrating the change in NOx emissions with engine speed are shown in Figure 9. The amount of NOx pollutants can change depending on the conditions of operation and the amount of Ethanol (E) in the mixture. Engine combustion increases oxides of nitrogen drop when gasoline is mixed with oxygen-containing ethanol. As the amount of ethanol in the fuel mixture rises, the

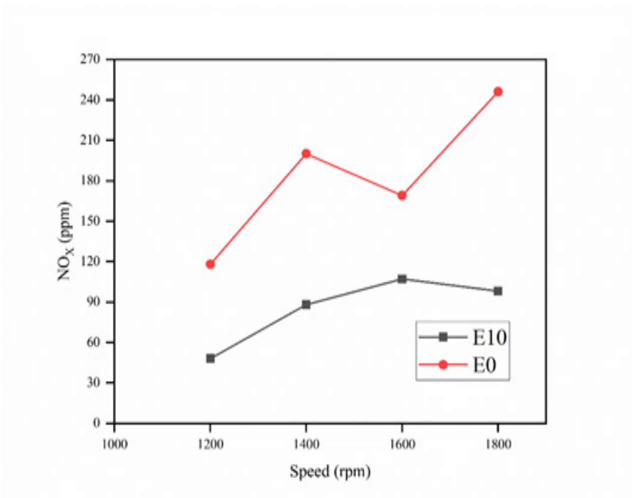

Figure 9. Variation in nitrogen oxide with speed.

concentration of NOx decreases. The water content of gasoline does not reduce the amount of alcohol, but it does have a significant impact on lowering pollutants.

In comparing E10 to E0, engine torque increased significantly, achieving an optimal level of 16.66% for 1800 rpm. The improved anti-knocking characteristics of gasoline blends containing ethanol, resulting in higher combustion pressure and improved engine torque, can be related to their higher-Octane Number (ON). Based on the testing results, Brake Torque (BT) was higher when using E10 fuel blends over E0. At 1800 rpm, E10 brake power increased by 1.45% as compared to E0 because alcohol blends have lower stoichiometric AFR ratios and a higher heat of vaporization, they drastically reduce fuel-air charge. This increases the charge density and, consequently, their Brake Power (BP) in comparison to gasoline. At 1800 rpm E10 decrement in BSFC was 0.34 Kg/Kwh as compared to the regular gasoline (E0). Because conventional gasoline (G) has a higher Calorific Value (CV) than Ethanol (E). Gasoline-Ethanol (GE) mixtures usually employ more fuel than E0. However, at CR 10, the E10 blend demonstrated a significant decrease in BSFC. As a result, Carbon monoxide exhaust emissions from E10 were decreased by about 1.1% as compared to E0. Blending Gasoline (G) with oxygen-containing ethanol improves combustion and lowers CO pollutants. CO_2 exhaust emissions from E10 were marginally higher by approximately 3.9% at 1800 rpm when compared to E0. Gasoline-Ethanol (GE) mixture has lower carbon levels than regular Gasoline (G). Additionally, the higher oxygen ratio in ethanol contributes to increased CO_2 emissions from E10 blends due to improved combustion efficiency. The main source of HC is unburned exhaust gas from incomplete combustion. Fuel additives such as methanol or ethanol marginally boost combustion and lower hydrocarbon emissions. All test fuels had significantly lower HC emissions as engine speeds and ethanol-gasoline blend percentages increased. At 1800 rpm, E10 reduces HC emissions up to 3.5% when compared to regular gasoline. In comparison to pure gasoline (E0), gasoline-ethanol blends were estimated to reduce NOx emissions by 2.53% at all engine speeds.

4.0 Conclusions

From experimental results, engine torque was seen to be higher for E10 than E0. At 1800 rpm, a maximum 16.66% increment was noted for E10 in comparison to E0. As indicated by the test results, there was an increase in Brake Power (BP) for E10. For E10, a maximum increase of 1.39 % (4.68 kW) was noted at 1800 rpm. In comparison to regular gasoline (E0), the E10 decrement in BSFC at 1800 rpm was 0.34 kg/kWh. Carbon monoxide exhaust emissions from E10 were approximately 1.1% lower than those to E0, based on the emissions results. At 1800 rpm, the CO_2 emissions from E10 were slightly higher than those from E0 by about 3.9%. At 1800 rpm, E10 reduces HC emissions by nearly 3.5% than gasoline. The NOx emissions from gasoline-ethanol blends were estimated to be 2.53% lower at all engine speeds than E0. Ethanol has a reduced calorific value, which decreases its mileage and power output. While gasoline is hydrophobic, ethanol is hygroscopic and that's why corrosion as well as non-starting engines can be caused by fuel contaminated with water. Longer storage of ethanol fuel gives restrictions due to its tendency towards corrosivity. Ethanol can specifically harm rubber parts such as gaskets and O-rings, resulting in leakage. Limitations that are in addition to inhibitors or additives, as well as BS-IV engine, are used in experimental work. To work with blends higher than 10 %, such as M100, E85, and Flex-fuel, and to develop additives as well as to raise the CR of vehicles/ engines. Additionally, it must work with various vehicle models and the BS6 engine model. An engine should be modified to use the GEM blend without suffering from any operating problems.

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