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Research Article

Impact of Isopropyl Alcohol Addition on Engine Performance in Gasoline Engines

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Abstract **–** Internal combustion engines use alternative fuels to meet the rising need for energy. Alcohol are among the best alternative fuels that can be used in spark-ignition engines without any structural modifications. With their high oxygen content and fast burning rate, alcohols can increase engine efficiency while reducing harmful emissions. The performance of spark-ignition engines was experimentally studied in this study to determine the impacts of employing various isopropyl alcohol ratios. Under full-load conditions and using various engine speeds, the experimental investigation was done. The experimental results showed slight decreases in engine torque with the addition of 10% and 20% isopropyl alcohol. The specific fuel consumption also increased slightly with the addition of alcohol. However, the effective efficiency showed only small decreases with the addition of alcohol. It was found that the percentage changes in the engine performance characteristics were 3.5%, 3.6%, and 2.8%, respectively, for effective efficiency, effective power, specific fuel consumption, and effective efficiency.

Keywords – Isopropyl Alcohol, Engine Performance, Alternative Fuels, Experimental Study

I. INTRODUCTION

The rapid increase in the world population and the rise in industrialization have increased energy demand [1]. There is a demand for alternative fuels to petroleum-based fuels to meet the growing energy needs. In spark-ignition engines, alternative fuels such as ethanol, methanol, isopropyl alcohol, hydrogen, LPG, CNG, and LNG are used [2,3].

Alcohols are classified with the formula CnH2n+2O. They are colorless and have a sharp smell. Alcohols contain a certain amount of oxygen in their structure. Due to their positive properties, such as high oxygen content, low latent heat of vaporization, fast flame speed, and complete combustion, alcohols are used as fuels in gasoline engines without any modifications [4,5]. Compared to conventional motor fuels, alcohols have smaller molecular structures, contain oxygen, and do not include sulfur, carcinogenic substances, and heavy metals, resulting in positive effects on exhaust emissions [6,7]. This leads to brighter and faster combustion. Increasing the flame speed improves combustion efficiency and ensures stable engine operation [8,9]. Moreover, fast combustion allows for higher compression ratios, leading to increased efficiency without engine knocking. The combustion rate significantly affects engine performance and changes in exhaust emissions [10,11].

Isopropyl alcohol is considered an environmentally friendly alternative fuel. It can be blended with gasoline and used in gasoline engines, reducing harmful emissions. The high oxygen content and fast burning rate of isopropyl alcohol enhance engine efficiency, leading to cleaner and more efficient combustion.

Hsieh et al. conducted a study to investigate the effects of different ethanol-gasoline blends on engine performance and exhaust emissions in a gasoline engine. According to the test results, an increase in the ethanol content in the blend led to an increase in engine torque and specific fuel consumption. However, it was observed that as the ethanol content in the blend increased, the unburned HC and CO emissions decreased due to the lean mixture formation [12]. Özsezen and Çanakçı examined the effects of different ratios of gasoline-ethanol and gasoline-methanol blends on engine performance parameters experimentally. The results obtained from tests conducted on a chassis dynamometer showed that vehicles running on alcohol-gasoline blends slightly increased wheel power and specific fuel consumption compared to vehicles running on gasoline alone [13]. Eyidoğan et al. mixed ethanol and methanol with gasoline at different ratios. The results showed that blended fuel reduced exhaust emissions, initiated early heat release and cylinder gas pressure rise, and increased specific fuel consumption [14]. Ayhan et al. investigated the effects of three different alcohol fumigations on a diesel engine experimentally. They applied ethanol, methanol, and isopropyl alcohol to the intake manifold at a mass ratio of 10%. The experimental study revealed engine performance parameters improvements and exhaust emissions reductions [15]. When gasoline, methanol, and ethanol fuel blends were used, it was found that brake power decreased, brake-specific fuel consumption increased compared to gasoline, and as the percentage of fuel blends increased, CO and HC concentrations decreased, but NOx emissions increased significantly when the fuel blending percentage reached 30% [16].

This study aims to experimentally investigate the effect of isopropyl alcohol addiction on engine performance in gasoline engines. The experiments analyze the changes in engine performance when different ratios of isopropyl alcohol-gasoline blends are used.

II. Materials and Method

A dual-cylinder Lombardini gasoline engine was used as the test engine for fuel evaluation. Experimental study was carried out with the engine at full load and different engine speeds. In the experiments, the engine was first run on gasoline, and after reaching a stable operating condition, experimental data was recorded. The engine was then operated using a blend of gasoline and isopropyl alcohol. The experimental setup is illustrated in Figure 1.

A 20 kW electric dynamometer was used to measure engine performance in the test setup. A mass flow fuel meter was used to determine the fuel consumption. The fuel tank was placed on a balance with a precision of 0.01g, and the fuel flow rate at a specific time was measured.

In the studies, both gasoline and mixed fuels were used. Using a magnetic stirrer, the mixed fuels were prepared by mass, guaranteeing that there was no phase separation during the preparation process. Both a 10% isopropyl alcohol and 90% gasoline blend (I10) and a 20% isopropyl alcohol and 80% gasoline blend (I20) were used in the studies.

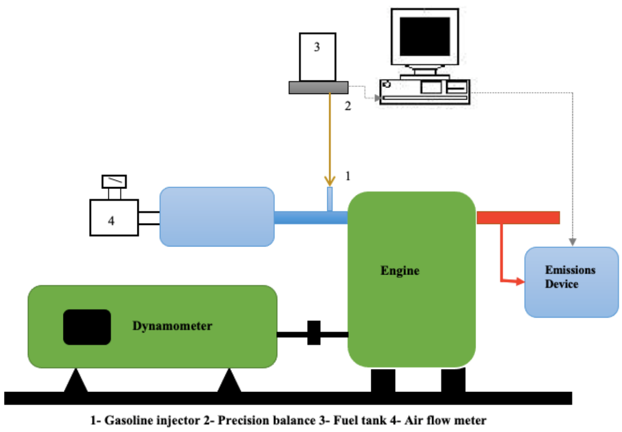

Fig. 1 Schematic view of the experimental setup

The experiments were conducted by running the engine on gasoline until it reached a stable operating condition, after which the blended fuels were tested. Three replicates were performed for gasoline and blended fuels, and the results were averaged.

The following formulas were used to determine the engine performance parameters:

The generated torque and power by the engine were calculated using the following formula.

$$M_d = F.L \qquad (Nm)$$

$$P_e = \frac{2\pi.F.L.n}{1000} \qquad (kW)$$

Here;

Md = Torque (Nm),
F = Brake load (N),
L = Moment arm length (m),
Pe = Effective power (kW),
n = Engine speed (rpm).

Effective efficiency is the ratio of the work obtained from the engine crankshaft to the energy supplied to the cylinder. my is the mass flow rate, and Hu is the lower heating value of the fuel.

$$\eta_e = \frac{P_e}{\dot{m}_y . H_u}$$

Specific Fuel Consumption (SFC) is the fuel consumed per unit of power output. SFC is calculated using the mass flow rate (my).

$$SFC = \frac{3600.\dot{m}_y}{P_e}$$

III. DISCUSSION

In spark-ignition engines, alcohol-gasoline blends are used as an alternative to petroleum-derived fuels. This allows for both an alternative to gasoline fuel and improvements in emitted emission values. In a gasoline engine, when gasoline and gasoline-isopropyl fuel are used, the torque values obtained from the engine are given in Figure 2. When the figure is reviewed, it can be seen that the torque for I10 and I20 gasoline-isopropyl blended fuel falls at all engine speeds. The maximum reduction in torque value is obtained in I20 blended fuel. The maximum decrease rate of I10 blended fuel compared to gasoline fuel is 1.7% at 2200 rpm. The maximum decrease rate in the I20 blended fuel is 3.6% at 2200 rpm. The decrease in engine torque is caused by isopropyl alcohol's decreased heating value compared to gasoline fuel. Because of this, the blended fuel engine produces less power and torque than an engine powered by gasoline because its energy output is lower.

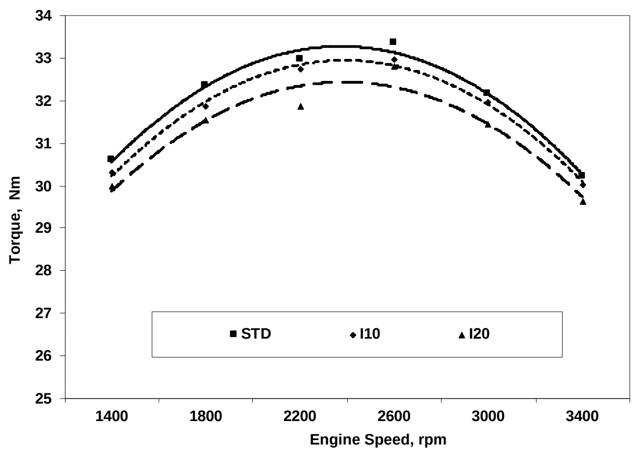

Fig. 2 Torque changes

Figure 3 shows the variations in engine effective power with regard to engine speed. When the figure is analyzed, it can be seen that there are reductions in effective power at all speeds compared to the gasoline fuel engine data when various gasoline-isopropyl blend ratios are employed in the engine. The maximum reduction in effective power is obtained in the I20 blended fuel. The decrease in effective power is because blended fuel has lower energy than gasoline fuel. Additionally, the latent heat of the vaporization of alcohol causes a cooling effect inside the engine, leading to increased oxygen intake. However, this increase is not sufficient to increase the torque amount.

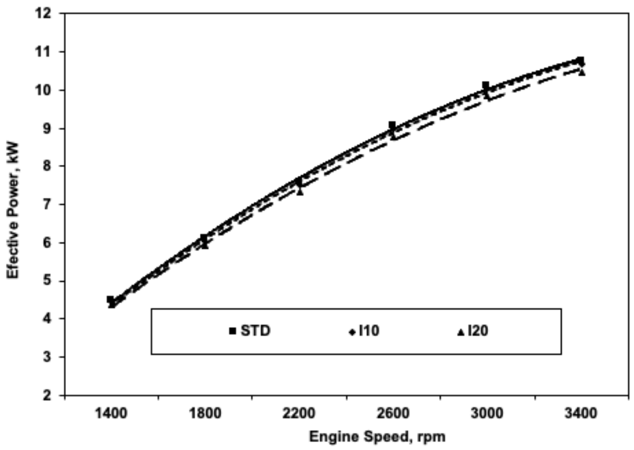

Fig. 3 Effective Power changes

Figure 4 shows the engine's specific fuel consumption values for various gasoline-isopropyl alcohol blend ratios. When the figure is examined, it is observed that blended fuel has higher specific fuel consumption values at all speeds compared to gasoline fuel. The I20 blended gasoline has the biggest increase in specific consumption of gasoline. The maximum increase rate of the I10-fueled engine compared to the STD condition is 1.7% at 2200 rpm. In the I20-fueled engine, the maximum increase rate is 2.8% at 2200 rpm. The increase in specific fuel consumption in blended fuels is because alcohol has a lower calorific value compared to gasoline fuel and lower density. Additionally, due to their high stoichiometric fuel/air ratios, blended fuels use more fuel for the same output power.

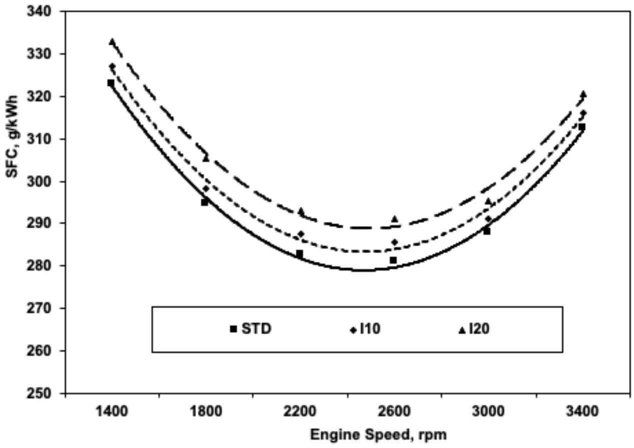

Fig. 4 SFC changes

In Figure 5, the engine's effective efficiency values with different ratios of gasoline-isopropyl alcohol blends are shown. When the graph is looked at, it becomes clear that using blended fuels in the engine reduces effective efficiency at all speeds. At 2200 rpm, the I10-fueled engine's maximum reduction rate in relation to STD conditions is 1.6%. At 2200 rpm, the I20-fueled engine's maximum fall rate is 3.5%. The reason for the changes in effective efficiency is the lower calorific values and densities of alcohols. Consequently, more fuel needs to be consumed to provide the same power output.

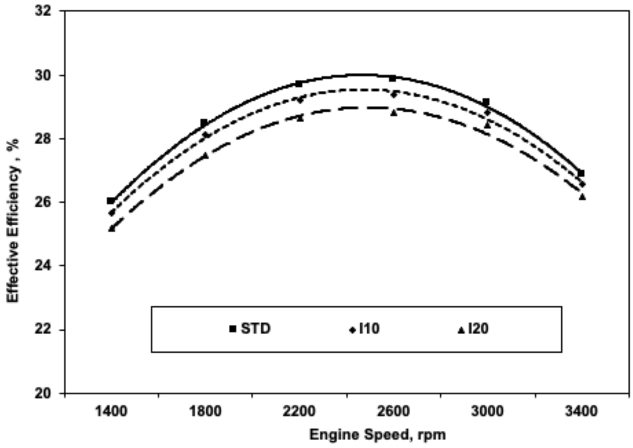

Fig. 5 Effective Efficiency changes

In Figure 6, the lambda values with different ratios of gasoline-isopropyl alcohol blended fuels in the engine are shown. When the graph is looked at, it can be seen that using blended fuels raises lambda values in comparison to gasoline fuel. The lambda value is a crucial metric that shows the fuel-air mixture value and has an impact on how exhaust emissions are formed. An increase in lambda value suggests an excess of oxygen in the mixture. Because of the improved combustion efficiency brought on by the mixture's increased oxygen concentration, lower exhaust emission values are produced.

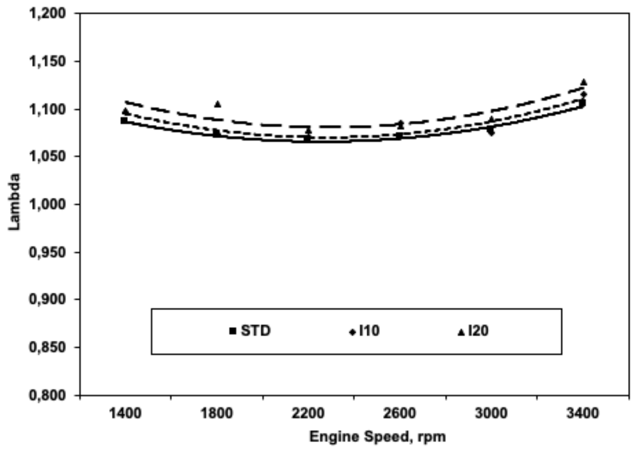

Fig. 6 Lambda changes

IV. CONCLUSION

Due to the increasing population rate, existing energy sources are decreasing, and there is a need for alternative fuels in engines to meet the energy demand brought by the growing population.

Additionally, petroleum-based fuels cause environmental pollution and contribute to global warming. This study examines the effects of gasoline-isopropyl alcohol fuel blends on engine performance parameters as an alternative to gasoline fuel.

According to the results of the experiments, utilizing gasoline-isopropyl alcohol blends in engines resulted in a reduction in engine torque. The I20 mix ratio has experienced the most decline. When comparing the specific fuel consumption to gasoline fuel, it is shown that blended fuel increases specific fuel consumption. Additionally, compared to gasoline fuel, the engine's use of blended fuels causes a reduction in effective efficiency.

In conclusion, isopropyl alcohol positively affects the performance and emissions of gasoline engines. As a renewable and sustainable fuel source, isopropyl alcohol provides an important solution to reduce the environmental impact of gasoline engines.

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