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PERFORMANCE ANALYSIS OF A SMALL INTERNAL COMBUSTION ENGINE WITH GASOLINE AND E85 ETHANOL BLEND

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ABSTRACT

This study investigates the performance characteristics of a small three-cylinder internal combustion engine when fueled by both gasoline and a gasoline-ethanol e85 blend. With the aim of understanding the potential benefits of ethanol blending in small engine applications, torque, power, and brake mean effective pressure were comprehensively evaluated using a dynamometer setup. Measurements were conducted within the engine speed range of 2500 to 4100 rpm, covering typical operating conditions for small engines in automotive applications. The experimental results demonstrate a slight improvement in engine performance with the utilization of the e85 blend compared to pure gasoline. Specifically, the e85 blend exhibited increased torque and power outputs across the operating range. These findings suggest promising opportunities for enhancing the performance and efficiency of small internal combustion engines through the adoption of ethanol blends.

KEYWORDS: Internal combustion engines, ethanol e85, engine performance, dynamometer.

1. INTRODUCTION

Internal combustion engines have long been the backbone of numerous industries, from transportation to power generation. However, amid growing concerns about environmental sustainability and the need to diversify energy sources, there is a renewed interest in exploring alternative fuels and their effects on the performance of these engines. The primary interest lies particularly in the automotive industry due to the significant amount of pollutant emissions produced. In order to reduce the consumption of foil fuels, environmentally friendly fuels are an effective option for powering internal combustion engines (Bae & Kim, 2017), (Martins & Brito, 2020). Different research studies have been conducted to study the performance of engines under different conditions and with different types of alternative fuels. Norouzi et al. (Norouzi et al., 2021) performed an energy and exergy analysis of internal combustion engine performance of spark ignition for gasoline, methane, and hydrogen fuels. They found that increasing the engine speed also increases the exergy transfer with engine work. Berlini et al. (da Costa et al., 2020) carried out an investigation of a dual-fuel engine powered by biogas and bioethanol, for two liquid fuel replacements of 20 and 50% by energy. Experiments were conducted using a modified compression ratio in a spark-ignition single-cylinder engine, varying engine speeds and loads. The results demonstrate that dual-fuel operation enhances combustion rates and completeness compared to single-fuel biogas operation, resulting in decreased carbon monoxide and unburnt hydrocarbon emissions, thus improving combustion efficiency. Szwaja et al. (Szwaja et al., 2022) investigates the performance of an internal combustion engine proposing a new type of fuel o f a completely renewable origin based on ethanol and glycerol at the ratio of 3:1 (75% and 25%), respectively. They found that the emissions of CO, NO_x, and unburnt hydrocarbons showed similar results to the gasoline fuel emissions tests, also the indicated mean effective pressure decreased by less than 3%. Kar et al. (Kar et al., 2021)outlines an experimental inquiry into a downsized and enhanced, 4-cylinder spark ignition engine utilizing either directly injected compressed natural gas (DI CNG) or gasoline (GDI) as fuel. It explores three distinct methods for preparing the charge for both fuels: stoichiometric engine operation without external dilution, stoichiometric operation with external exhaust gas recirculation (EGR), and lean burn. Initially, the study demonstrates that the optimized DI CNG engine's performance matches that of the baseline GDI engine under stoichiometric conditions, achieving similar peak torque levels at lower engine speeds and offering notable fuel economy benefits. Ayad et al. (Ayad et al., 2020) experimental and computational examination of a turbocharged ethanol engine operating with hydrogen enrichment under boosted conditions at stoichiometric levels. These findings revealed that the addition of hydrogen enabled spark ignition engines to achieve reduced brake-specific energy consumption, enhanced performance, and decreased emissions. A simulation model was developed and validated as an effective tool for forecasting engine performance in spark ignition engines utilizing hydrogen enrichment, thereby minimizing the necessity for numerous experimental tests to optimize engines operating with this fuel mixture. Nguyen et al. (Khoa & Lim, 2022) evaluated the impact of combustion duration on the performance and emission characteristics of a spark-ignition engine fueled by pure methanol and ethanol. Their findings demonstrate that elongating combustion duration leads to a decline in peak firing temperature and pressure, while resulting in an augmentation of trapped residual gas. An extension in combustion duration contributes to a reduction in NOx and HC emissions, albeit an increase in CO emissions was observed. Most of the fuels analyzed in the mentioned research are not available for commercial use. Ethanol is one of the most accessible fuels and can be used mixed with conventional gasoline. In this work a comparison of the performance of a spark-ignition internal combustion engine fueled with pure gasoline and a mixing of gasoline 90% and 10% ethanol. Experimental measurements of power and torque were performed and with the obtained data the break mean specific pressure (bmep)was calculated.

2. METHODOLOGY

The measurements were conducted on a biofuel compatible three-cylinder engine. The engine has a displacement of 1198 cc, the bore and stroke are 76.5 mm and 86.9 respectively. The engine is ensembled in an Armfield CM11-KII instrumentation system. An eddy current dynamometer is included in the system and provides variable load. A more detailed description of the full system can be consulted in (Armfield, 2019). The full system is presented in Figure 1.

Figure 1: Armfield CM11-KII instrumentation system.

The dynamometer system used in this study is designed with the capability to work with both gasoline and biofuels. In this work, measurements were carried out using two fuels. The first one is regular gasoline of 89 octanes with a density of 740 kg/m^3 and a lower heating value of 42.83 MJ/kg. The second one was a mixture of regular gasoline and ethanol e85. The properties of the e85are 96 octanes, a density of 789 kg/m^3 and a lower heating value of 29.6 MJ/kg. The blend consists of 90% gasoline and 10% E85. This proportion was defined based on the limitations of the internal combustion engine.

Measurements were obtained from 2500 to 4100 rpm at intervals of 200 rpm. At each interval 50 data were taken. For all measurements the load was 65%. Torque and power were the data obtained from the measurements. To calculate the bmep the next equation was employed:

$$bmep = \frac{\tau 4\pi}{V_d} \qquad (1)$$

Where τ is the torque, V_d is the displacement volume from top dead center to bottom dead center. The number 4 indicates a four-stroke cycle. The $V_d$is and is calculated by means of

$$V_d = \frac{\pi}{4} B^2 SC \qquad (2)$$

Where B is the bore, S is the stroke and C is the number of cylinders. The obtained results were adjusted using an order 4 polynomial fit. Finally, in Figure 2, the software used on the dynamometer to acquire the results is being presented.

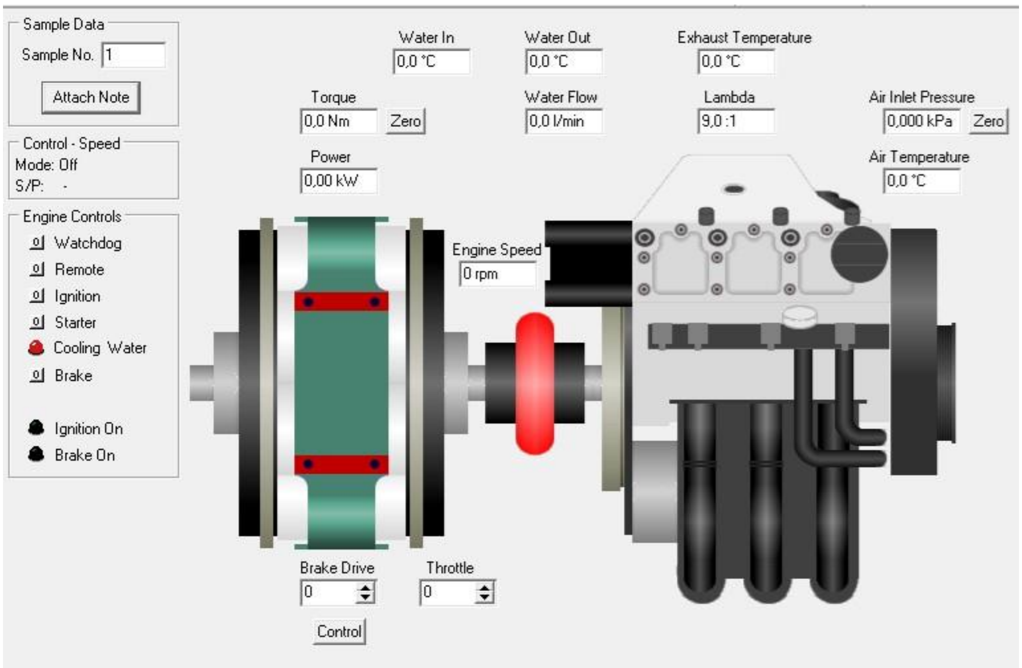

Figure 2: Presentation of the software used on the dynamometer for acquiring results.

3. RESULTS

In Figure 3, the results of torque for both fuels are presented. It is observed that the mix gasoline-e85 increased this magnitude by around 2% compared to only gasoline fuel. This behavior remains consistent throughout most of the measured range. Additionally, it is remarkable that the maximum torque peak was reached at 3392 rpm in both cases. The values of R^2 for gasoline and gasoline-e85 fit were 0.9497 and 0.8742 respectively.

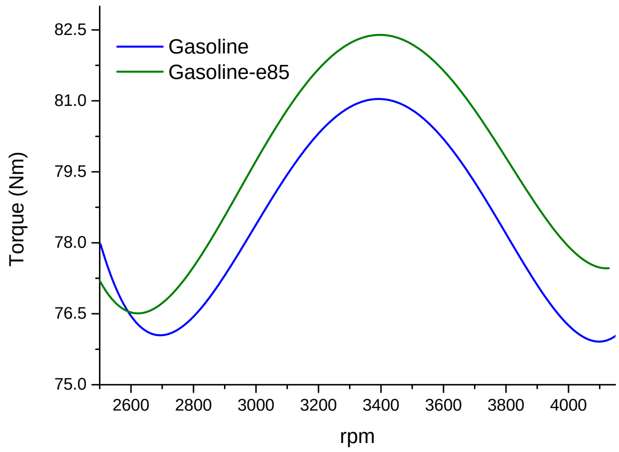

Figure 3: Comparison of torque.

The comparison of power is presented in Figure 4. The trend remains in power measurements. The percentage of increment is around 2% and occurs at 3916 rpm, afterwards this difference decreases slightly, whereas, at lower rpm, below than 3000, the difference is less than 1%. Curve fitting yielded highly favorable values, approaching unity, being the values of R^2 0.9989 and 0.9971 for gasoline and gasoline-e85 respectively.

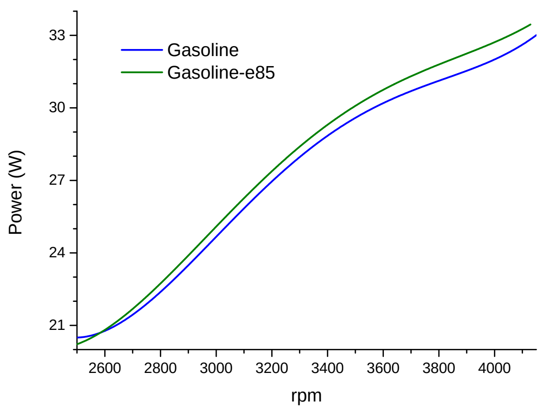

Figure 4: Comparison of power.

The behavior of torque is replicated in the comparison of bmep presented in Figure 5. The combination of gasoline and e85 increases the magnitude of bmep. This difference is maximum at 3392 rpm. Furthermore, the difference decreases slightly, however, it is greater than at low revolutions.

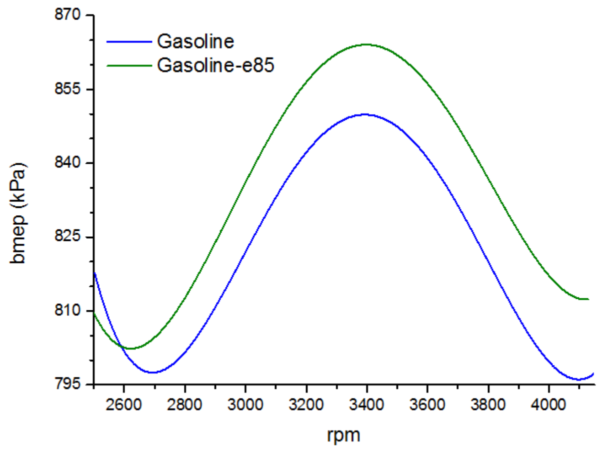

Figure 5: Comparison of bmep.

Based on the results, the performance of the internal combustion engine increases around 2% in all the analyzed parameters. The results are attributed to the fact that the e85 blend alters the properties of pure gasoline, including the number of octanes. The maximum torque and power were achieved at the same rpm; therefore, no influence of the gasoline-E85 blend was observed in this regard.

CONCLUSIONS

In this work, experimental measurements were performed to compare the performance of a small internal combustion engine with gasoline and a blend gasoline-ethanol e85. It is concluded that the use of a blend gasoline-e85 improves slightly the performance of an internal combustion engine. Due to the enhanced performance achieved by the blend, it is deemed applicable for small engines, which are more practical for automotive use. This performance enhancement can be particularly beneficial in compact vehicles, where fuel efficiency and power are crucial aspects for optimal operation. The insights gained from this study contribute to the broader understanding of alternative fuel utilization in automotive systems and pave the way for further research in this area.

REFERENCES

1. Armfield. (2019). *Gasoline Engines – CM11-MKII*. https://armfield.co.uk/wp-content/uploads/2020/05/CM11MKII_Datasheet_v1d_Web.pdf
2. Ayad, S. M. M. E., Belchior, C. R. P., da Silva, G. L. R., Lucena, R. S., Carreira, E. S., & de Miranda, P. E. V. Analysis of performance parameters of an ethanol fueled spark ignition engine operating with hydrogen enrichment. *International Journal of Hydrogen Energy*, 2020; *45*(8): 5588–5606. https://doi.org/10.1016/j.ijhydene.2019.05.151
3. Bae, C., & Kim, J. Alternative fuels for internal combustion engines. *Proceedings of the Combustion Institute*, 2017; *36*(3): 3389–3413. https://doi.org/https://doi.org/10.1016/j.proci.2016.09.009
4. da Costa, R. B. R., Valle, R. M., Hernández, J. J., Malaquias, A. C. T., Coronado, C. J. R., & Pujatti, F. J. P. Experimental investigation on the potential of biogas/ethanol dual-fuel spark-ignition engine for power generation: Combustion, performance and pollutant emission analysis. *Applied Energy*, December 2019, 2020; *261:* 114438. https://doi.org/10.1016/j.apenergy.2019.114438
5. Kar, T., Zhou, Z., Brear, M., Yang, Y., Khosravi, M., & Lacey, J. A comparative study of directly injected, spark ignition engine performance and emissions with natural gas, gasoline and charge dilution. *Fuel*, June 2021; *304:* 121438. https://doi.org/10.1016/j.fuel.2021.121438
6. Khoa, N. X., & Lim, O. Influence of Combustion Duration on the Performance and Emission Characteristics of a Spark-Ignition Engine Fueled with Pure Methanol and Ethanol. *ACS Omega*, 2022; *7*(17): 14505–14515. https://doi.org/10.1021/acsomega.1c05759
7. Martins, J., & Brito, F. P. Alternative fuels for internal combustion engines. *Energies*, 2020; *13*(15). https://doi.org/10.3390/en13164086
8. Norouzi, N., Ebadi, A. G., Bozorgian, A. R., Hoseyni, S. J., & Vessally, E. Energy and Exergy Analysis of Internal Combustion Engine Performance of Spark Ignition for Gasoline, Methane, and Hydrogen Fuels. *Iranian Journal of Chemistry and Chemical Engineering*, 2021; *40*(6): 1909–1930. https://doi.org/10.30492/ijcce.2022.539658.4948
9. Szwaja, S., Gruca, M., & Pyrc, M. Investigation on ethanol-glycerol blend combustion in the internal combustion sparkignited engine. Engine performance and exhaust emissions. *Fuel Processing Technology*, August 2021, 2022; *226:* 107085. https://doi.org/10.1016/j.fuproc.2021.107085