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Experimental Investigation of Alcohol Blending Effect on the Performance of a Single Cylinder Spark-Ignition Marine Engine

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Abstract

This work represents an experimental study on the performance of a single cylinder spark-ignition marine engine fueled by ethanol blends. Several studies have been carried out to investigate the use of alternative fuels in spark-ignition engines to improve their efficiency and reduce exhaust emissions. Experiments were conducted on DIDACTA-T85 engine test bed under full load condition with varied engine speed from 1000 rpm to 3000 rpm and an engine wall's temperature fixed between 75°C – 85°C. This study showed that E20 conducted for the best result in specific fuel consumption without notable loss in engine performances in comparison with other blends.

Experiments showed that ethanol blends are a viable option as a fuel alternative in spark-ignition engines due to its potential to conserve for acceptable engine performances.

Keywords: Alternatives, Combustion characteristics, Engine performances, Ethanol blends, SI engine

Research Article

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1. Introduction

In recent years, many studies have been carried out to investigate the use of alternatives to replace conventional fuels in SI engines [1-5] to improve their efficiency and to meet required standards. They are considered as a suitable option as a replacement for gasoline in SI engines due to their economic and environmental benefits. Gasoline is produced in oil refineries, which they are a big source of dangerous and toxic air pollutants; on the other hand, alternative fuels are produced from the fermentation of carbohydrates like ABE fermentation to produce acetone, butanol, and ethanol and by a synthetic process derived from a petrochemical reaction known by petrol biofuel [6-10].

Blended fuels are one of the most promising technology to reduce emissions and improve engine efficiency, there are several investigations have been conducted in this context. More attention has been focused on the use of oxygenated alternatives (alcohol, ether etc.) [11-13]

Ethanol (C2H5OH) is an oxygenated liquid hydrocarbon. It can be produced from renewable resources such as biomass. It has been used as a fuel for SI engines from many years. Several studies showed a great benefit of using ethanol blends in SI engines due to its chemical and physical properties [14-16]. Ethanol is a colorless fuel characterized by high latent heat of vaporization which can decrease the fuel consumption, the high octane number and the high flame speed of ethanol can allow for a high compression ratio and a high combustion efficiency comparing to pure gasoline. Also the high oxygen content in ethanol conducts to reduce exhaust emissions such as carbon monoxide (CO), since it is hugely dependent on oxygen content.

There have been many studies, both, experimental and numerical, conducted on the influence of using ethanol in SI engines. Chen et al. [17] have investigated the effect of ethanol blends on the characteristics of combustion and soot formation for direct injection SI engines. They found that for lower level ethanol blends it is possible to achieve a desirable combustion with less soot formation.

Gao et al. [18] investigated the impact of ethanol addition on inflame and exhaust soot. They found that there is a significant reduction in number counts and projection area for both the in-flame and exhaust soot particles with increasing ethanol blending ratio.

For all ethanol blending ratios, the projection area s and the number counts of exhaust soot showed a lower value than those of the in-flame soot.

Setyono et al. [19] have investigated the use of ethanol-gasoline blends as an alternative fuel for SI engine. They found that ethanol-gasoline blend G45 conducted for the highest engine performances and the less specific fuel consumption in comparison with G25 and G35.

Al-Hassan [20] investigated the effect of ethanol unleaded gasoline blends on engine performance and exhaust emission. The study showed an increase in brake power, torque, volumetric and brake thermal efficiencies, and a decrease in the brake specific fuel consumption and equivalence air-fuel ratio. This study showed that E20 gave the best results for all measured parameters at all engine speeds.

2. Experimental setup and procedures

Experiments were conducted on the engine test bench DIDACTA-T85D single cylinder, four stroke, water cooled spark-ignition marine engine, the specifications of the engine are illustrated in table 1. The tested bed consists of a control panel, dynamometric unit, mechanical coupling, a cooling circuit, and a fuel supply system. Fig.1 and Fig.2 show the experimental setup.

Table 1. Specification of the engine (BRIT IMP 5*hp*)

No. of cylinders	One
Cycle	4 strokes
Cooling	Raw Water
Bore	80.95 mm
Stroke	69.85 mm
Capacity	360 cc
Compression Ratio	8:1
Power	5 brake horse power

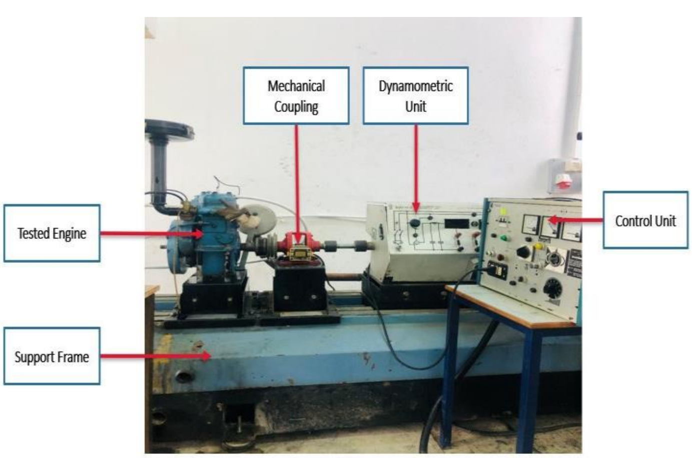

Fig. 1. Engine test bench

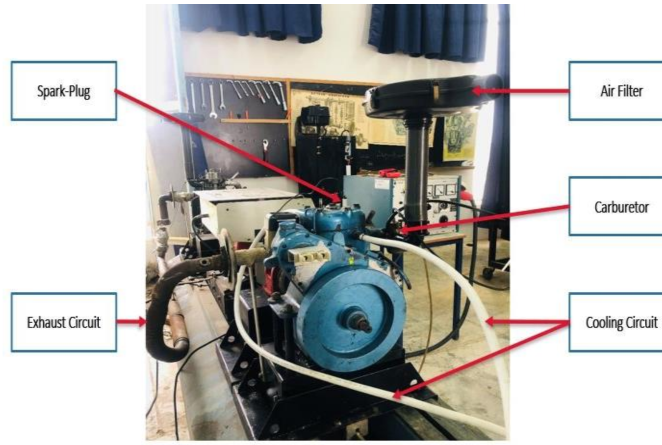

Fig. 2. Tested engine

3. Results and discussions

3.1. The effects of ethanol blending on the engine power

A commercial gasoline fuel considered as the basic fuel in this study was mixed with various blends of ethanol. The tested blends were E0, E5, E15, and E20 (0 vol. %, 5 vol. %, 15vol. %, and 20vol. %) of ethanol in gasoline.

Fig.3 shows the measured power output at different fuel blends and full load condition.

As it shown, there is a slight increasing in power output in the case of blends containing ethanol. This is can be explained by the higher oxygen content in ethanol comparing to gasoline, also blends with low quantity of ethanol in gasoline characterized by a lower heat value close to pure gasoline.

Results showed that increasing ethanol concentration in gasoline doesn’t conduct to an obvious increase in power output, as one can notice, E5 showed better results than E20, and E15 especially at low speed values and at 2500 rpm. This can be explained by the higher LHV of E5 in comparison with E15 and E20.

The effect of ethanol-gasoline blends on performance and exhaust emissions of a SI engine have been investigated experimentally through an exergy analysis by Dogan et al. [21]. They found that for all tested blends (E0, E10, E20, and E30) there was a slight loss in power compared to gasoline.

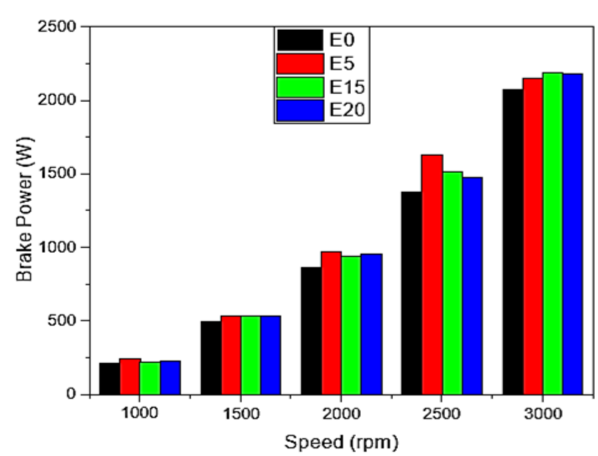

Fig. 3. Effect of ethanol blends on the engine power

3.2. The effects of ethanol blending on the engine torque:

Fig.4 shows a comparison result for the torque of the different fuel blends. As the same for the power, a slight variation in engine torque was observed.

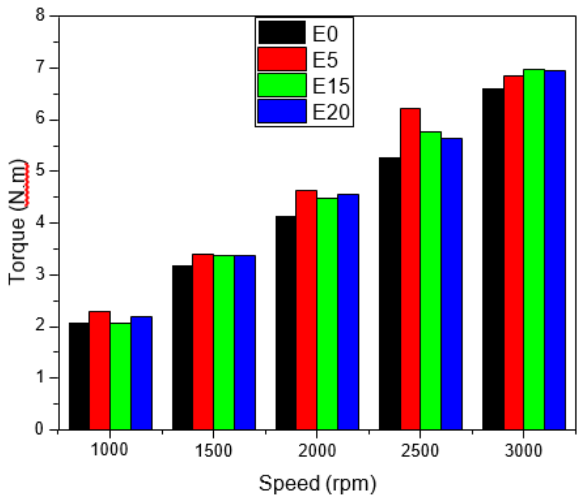

Fig. 4. Effect of ethanol blends on the engine torque

Adding ethanol to gasoline gives better results, in terms of developed torque, to that obtained for pure gasoline at different engine speeds. In some cases, as for E5, slight better results are obtained at engine speed less and equal to 2500 rpm. This is due to the high oxygen content and the close LHV of ethanol blends to pure gasoline. Same results have been obtained by M. Al-Hassan [20]. He found that adding ethanol to gasoline conduct to increase engine torque and E20 showed the best results at all engine speed.

3.3. The effects of ethanol blending on the engine fuel consumption

Results showed that adding ethanol to gasoline decreases significantly the fuel consumption, as it shown in Fig. 5. This is can be explained by the better evaporation quality of ethanol compared to gasoline.

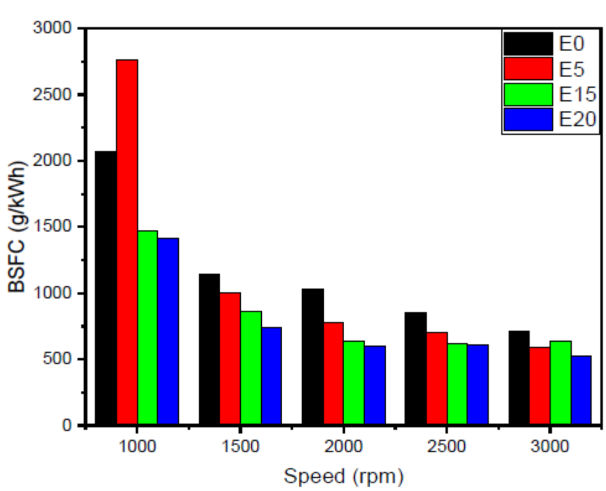

Fig. 5. Effect of ethanol blends on the Brake Specific Fuel Consumption

Also, it is clear to notice that increasing ethanol content in gasoline conduct to decrease fuel consumption, and E20 conduct to the lowest value over all engine speed, this is due to the high volatility of the blend.

Except in the case of E5, at low speeds, the fuel consumption increased, which can be explained by the fact that the effect of the lower heat value is more evident than the beneficial quality of ethanol in terms of easier evaporation.

A similar result was obtained by Saikrishnan et al. [22]. They found that E10 gives better results in comparison with E0, E5 and E15.

3.4. The effects of ethanol blending on the brake thermal efficiency:

Fig. 6 shows the evolution of the brake thermal efficiency over all engine speed. It is observed clearly that adding ethanol to gasoline improves significantly the thermal efficiency, this is due to the high flame speed of ethanol, conduct to a fast combustion process. It is also observed that increasing ethanol content in gasoline improves thermal efficiency in all engine speed. A similar result was obtained by M. Al-Hassan [20]. He found that E20 showed the highest value.

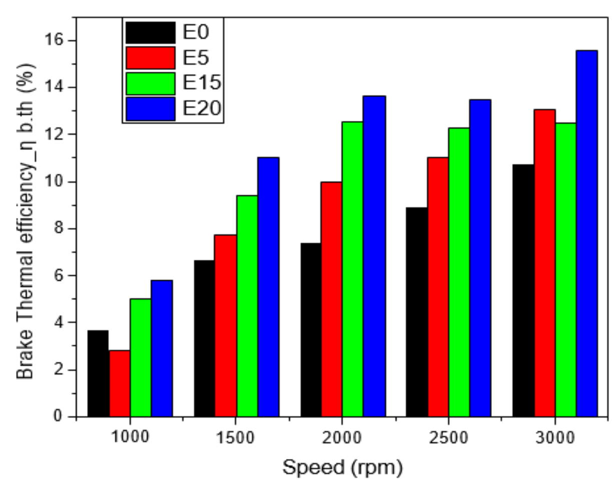

Fig. 6. Effect of ethanol blends on the brake thermal efficiency

4. Conclusions

The main objective of this research was to investigate experimentally, the effect of the addition of a small quantity of ethanol on a gasoline marine engine performance.

The experiment was carried out using a single cylinder water-cooled SI engine.

Comparisons between pure gasoline E0 and various ethanol-gasoline blends E5, E15, and E20 were made for power, torque and SFC. Measurements were obtained by varying the engine speeds at full load.

The experimental results have demonstrated that:

- Adding ethanol to gasoline in low quantity results in an increase in brake power, torque and brake thermal efficiency comparing topure gasoline.

- Specific fuel consumption decreases with adding ethanol in gasoline.
- Ethanol blends could be used as a fuel candidate in SI engines, without any technical modifications, due to its potential to conserve acceptable engine performances compared to pure gasoline.

This work represents the first step of a more developed research which will be carried out using further quantity and different types of alcohols.

Nomenclature

ABE	:	acetone-butanol-ethanol
Cs	:	specific fuel consumption
CO	:	carbon monoxide
E	:	ethanol
HC	:	unburned hydrocarbon
N	:	torque
LHV	:	lower heating value
SI	:	spark ignition
P	:	power output
rpm	:	revolution per minute

Conflict of Interest Statement

The authors declare that there is no conflict of interest in the study.

CRediTAuthor Statement

Mehrez Gassoumi: Investigation, Writing-original draft, Writing - review & editing,
Fakher Hamdi: Investigation, Visualizatio,
Zouhaier Boutar: Validation, Formal analysis,
Ridha Ennetta : Conceptualization, Supervision, Project administration,
Hakan Serhad Soyhan: Conceptualization, Supervision

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