Enhancing gasoline fuel characteristics and engine operation criteria using by product octan boosters

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Received: 17-11-2021, **Accepted:** 23-12-2021, **Published online:** 02-02-2022

Abstract. The increase of energy demand and environmental contaminations hearten the utilization of alcohol-bases as a alternatives fuels in spark ignition (SI) engine. The fusel oil is a byproduct developed from fermentation process with higher alcohol content. It has high-octane and slight exhaust emissions, there for it takes important place between the substitutes fuels. During this study, effect of used mixtures of pure low octane gasoline & fusel oil on engine exhaust emissions & performance have been estimated after water removal from fusel oil. A single-cylinder, four-stroke SI engine has been used in this tests. The inspections execute at different speeds. The test fuels mixed by fusel oil at ratio of 5%, 10%, 20%, and 30%. In each speed, the engine's performance & emissions size have been conducted. During the investigations, it have been observed that the brake power (BP) and specified fuel consuming (SFC) rises as the size of fusel oil risen in the mixture.

Keywords: Gasoline, SI engine, Octane number, Fusel oil, Brake power.

Introduction

Environmental pollution and the speedy decrease of reducing fossil fuels have reasons rising the need to usage substitute fuel in (SI) engines [1]. Hence, biofuels industrial of stuffs can be grown, which have advanced thermal efficiency and lesser emissions of exhaust [2]–[7]. Alcohol based as exchange fuels presently vastly considered. Fusel oil is along chains alcohol group sub-product of alcohol created through the distillation procedure [8]–[12]. Its odor is bad and its tint is dark brown. It has similar properties of alcohol fuel like as high (RON=106), (MON= 103), and also has higher oxygen contented about (30.23)%, with solo ebullition point, but fusel oil has high water contented about (3-20)% [13]–[20]. These advantage indicated that fusel oil may be utilized as substitute fuel or as additive to gasoline for sparkle ignition (SI) engines [21][22]. Sundry studies have scrutinized fusel oil-gasoline mixture impact on the performance of SI engine and emissions [10]. Calam showed that fusel oil can be used in SI engine as substitute fuel because of its physical & chemical characteristic. Increasing blends effects on torque of engine and fuel consumption, they were debated with many researches [21]. Also Calam and Icingur [21] used other fuel blend (10, 20, 30%) for operate spark ignition engine in diverse speed beneath higher load situations. The results exposed that the BSFC improved in all test situations at a maximum value of about 7.7 % with F30, after the proportion of the fusel oil raised in mixture, engine torque reduced. Furthermore, in wholly fusel oil-blends, NOx emissions reduced compared by pure gasoline for the reason that the decrease in engine exhaust temperature [23]. Calam et al. studied single-cylinder gasoline SI engine, they utilized another fusel oil mixing ratio (0%, 5%, 10%, 20%, 30% & 50%) with different load and stable speed of 3500 rpm. In this study the fusel oil presented as a renewable fuel for SI engine because of its physical-chemical properties. The result showed an increasing in BSFC and torque with a decrease in NOx [21]. Also solmaz claimed that the torque was reduced commonly into 6% and 2% at using of F100 & F50 fuel with adding of fusel oil ,while BSFC raised [24]. Suleyman & Bulent definite that, by addition of fusel oil in to untainted gasoline, engine torque and SFC increased. Furthermore, when fusel oil size increased in the mixture, NOx, CO2 and UHC emission decreased [25]. [26] Other study studied fusel oil at adding ratio of (0, 50 and 100%) to gasoline. The outcomes of the study was collected at speed of 2500 rpm and 4 load level of 25, 50, 75 & 100%. The outcomes showed that when fusel oil content raised the indicated mean effective pressure (IMEP) and heating value reduced because of water in fusel oil. Moreover, NOx decreased with 31% for F100 [27]. A study presented by Calam et al. showed important effect of fusel oil and gasoline blend percentage (5, 10 , 20 & 30%) on SI test execution and its emissions. Also Omar [28] presented a study showed the impact of water removal from fusel oil on heating value and engine performance. The test steered on SI motor below 4500 rpm motors speed by using different mixing fraction of gasoline & fusel oil (G100, FBWE10, FBWE20, FAWE10 and FAWE20), engine performance and heating value were improved. The results shown that by increasing ratio of fusel oil in mixture, significant increasing in octane number of blended fuel is obtained.

The objective of this study is to show the most suitable use for fusel fuel in SI engine that attain the best engine efficiency at maximum contamination protection. Different ratios of fusel oil and pure gasoline have been employed in this study to specify the better additive ratio.

Investigational organization

Experiment fuel. In this study, engine test was scab with pure gasoline, fusel oil & gasoline mixes after water elimination form (fusel oil) and enhanced gasoline as a threshold for comparison. Fusel oil supplied from Eskişehir sugar factory, that production ethyl alcohol (99.5%) pureness. Pure gasoline fuels have been obtained of native petrol stations in Iraq and indicated as commercial fuel. Pure gasoline (F0%) , (pure gasoline & fusel oil mixtures) applied in the experimentations, and the mixes are show in Table (1).

Water extraction. Fusel oil has similar characteristics as alcoholics fuels as (RON = 106), and (MON = 103), it has high oxygen contented, solo ebullition point, so it can be used as substitute fuel to (SI) engines [21]. However, water content of fusel oil is high (nearly 3-20%) which lead to reduction its heating value, and that lead to an adverse effect on the efficiency of combustion and performance of engine. Fusel oils heating value was (30)(MJ/kg), which is fewer than for pure gasoline that about (44.598 MJ/kg) [29]. In this experiment (H2O) contented for fusel oil removed by using center fugue in laboratory of north oil company in Iraq/Kirkuk. After water extraction the heating rate of fusel oil become (33.8) (MJ/kg).

Table 1. Structure of Fuel Mixtures.

Sample	Structure
(F0%)	Pure Gasoline
(FWE5%)	(5%) Fusel Oil + (95%) Pure Gasoline
(FWE10%)	(10%) Fusel Oil + (90%) Pure Gasoline
(FWE20%)	(20%) Fusel Oil + (80%) Pure Gasoline
(FWE30%)	(30%) Fusel Oil + (70%) Pure Gasoline
(FS)	Enhanced Gasoline Structure

Figure 1. Center fugue

Engine test. Tentative experiments implemented on a small four-cycle sparkle engine kind Robin (EH17) spark timing and compressing ratio are fixed. Table (2) shows advise characteristic of used engine in implement the experiments for this exploration. Engine load arrangement comprises of a hydraulic dynamo meter fixed on a usual experiment basis. The quantity of water stock requisite to hydraulic dynamo meter extent is specified as a lower than (5) (L/min) in (1bar). Cell of electric burden kind (S) by a full burden ability of (15) N.m is attuned over with control measure [30].

Table 1. Engine characteristics.

Factors	Specifications
(Displacement)	(172) Cm
(Bore) × (cycle)	(67)mm × (49) mm
Arrangement	four cycle, sparkle - ignition, solo cylinder
Connect shaft length	(85) mm
Fuel	Gasoline
Compression percentage	(8. 5 :1)

Figure 2. Engine test rig

Results and discussion

The current conclusions of experiment contain; physical & chemical feature, heating value,(RON) research octane number, density and viscosity adding to investigational experiments of engine performance (BP, BSFC and BTE). The research done by using pure Gasoline fuel (F0) and (gasoline & fusel oil) mix (F5%,,F10%,,F20%,,F30%) & enhanced gasoline (FS) in a single -cylinder, four-cycle spark engine Robin (EH 17) working in speeds range of (1500 - 2700) rpm by a rise (300 rpm) & (100%) valve open (WOT). The engine operative settings were kept similar in nearly all experimentations as surroundings temperatures of ambient and air pressure & humidity.

Test fuel quality investigation. The properties for the fuel used in processing of internal burning engines indicates the extreme significant factors in relatives of competence and superiority of burning [31]–[39]. Chemical & physical properties scaled and debated in such paper comprised (heating value, octane number, density and viscosity). The objects calculated to seven fuel tested samples (Fusel oil (F), pure gasoline (F0), F5, F10, F20, F30, FS). The physical and chemical properties have been examined in laboratory of north oil company in Kirkuk.

Heating value. Heating rate is amount of ability which one kilo gram 0f fuel produces after its completely burned that scaled by (MJ/kg) unity by used oxygen bombs calorimeter. It is represent an important indicator for the fuel suitability to operate IC engine efficiently [40]–[48]. Fig (3) shows the experiment effects. The heating value for fusel oil (F) after H2O removal equal (33.8MJ/kg), however for pure gasoline F0 equal to (44.598 MJ/kg), so heating rate for enhance gasoline equal to (43.781 MJ/kg) and the heating value of F5 equal to (44.173 MJ/kg) it reduced about (-0.95%), and F10 was (43.625 MJ/kg) reduced about (-2.18%), and F20 was (42.125 MJ/kg) it reduced about (-5.54%), and F30 was (41.307 MJ/kg) it reduced about (-7.37%). The outcomes of the research tested fuels shown that heating rate was suggestively decreased by adding fusel oil because of its low heating rate.

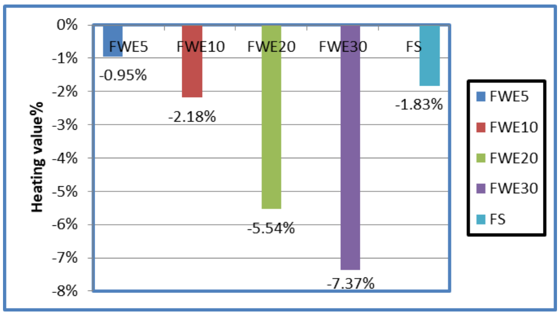

Figure 3. % Heating value change for tested fuel samples

Research octane number (RON). Research octane number (RON) is a measure of the fuel opposition to knockout of (SI) sparkle engines. The high octane (RON) for gasoline is the better ability of the gasoline to fight natural sparkle through compression & earlier sparkle ignition [49][50]. Advanced compression makes high temperature & high pressure which may be completed inside the cylinder of engine & takes in high engine energy. Fig(4) shows the outcomes for inspection of the(%) increasing of (RON) for tested fuels (F, F0, F5, F10, F20, F30, and FS). Fusel oil has aloft octane number (106) before water removal, therefore (RON) for tested fuel rise. RON of fuel (F0) was (86), and it increased when the fusel oil added. By adding F5 the octane number RON increased about (10.9%), it become (95.4), also by adding (F10) fuel, (RON) increased about (12.4%) to (96.7), the octane number RON for fuel (F20) increased about (11.6%) and found to be (96), and (F30) increased about (12.9%) to be (97.1).

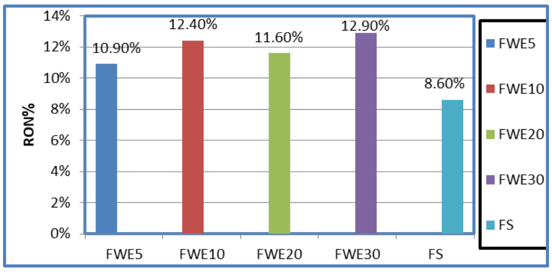

Figure 4. % RON change for tested fuel samples

Density. Density is the ratio among cluster and extend of fuel, it is a fuel physical feature which characters fuel frugality for engine through substitute procedure of equivalent burning and aloft density rises ability of density for a fuel [40], [51]–[55]. Also, high density produces high viscosity, that in order gifts bad burning and effect on engine performance & emission [56]–[63]. Fig(5) shows (%) fuel density increasing for (F5, F10, F20, F30, and FS) which found to be (769, 782, 789, 794, 774 kg/m³) respectively and raised about (0.9,2.6,3.5,4.1)% and(1.6%)for FS . The tested fuel densities were scaled at (20)Co by using (Digital Density Gage).

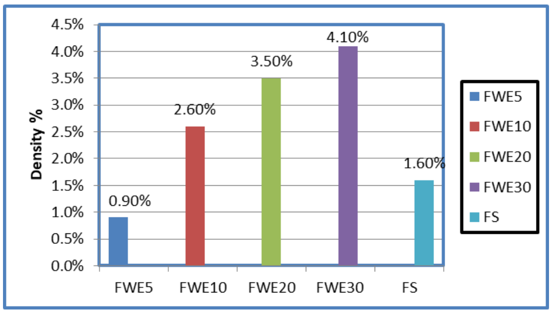

Figure 5. % Density change for tested fuel samples

Viscosity. Viscosity is a measure of internal rubbing or fuel fight to flowing, viscosity is a quite important quality for fuel, and it effect procedure treatment of fuel structure tools [38], [64]–[66]. The Kinematic viscosities of tested fuels were measured according (38C0) by using a viscometer. The viscosity of tested fuels (F, F0, F5, F10, F20, F30, and FS) were (2.896, 0.467, 0.514, 0.521, 0.594, 0.732, and 0.468) mm²/sec respectively. Because of fusel oil (F) high viscosity compared with pure gasoline, viscosity of pure gasoline increased with the addition of fusel oil. Fig (6) shows the % increasing of viscosity.

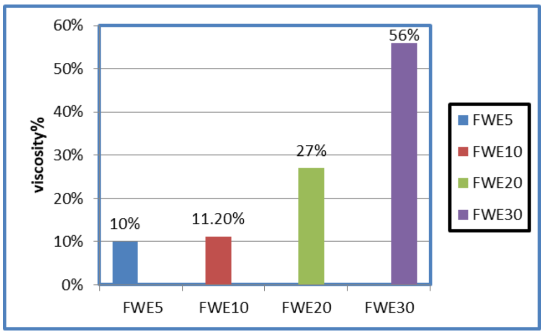

Figure 6. % Viscosity change for tested fuel samples

Engine performance

Brake power (BP). The engine brake power competence studied based brake torque of engine per rapidity [55], [67]–[73]. Engine torque rises by addition of fusel oil and increasing the speed of engine. At compared (fusel oil & gasoline) mixes of (F5, F10, F20, and F30) with pure gasoline (F0), the engine torque presented a little increase. The reason of engine torque increasing at the increasing of quantity of fusel oil, considered to high oxygen contain of the fusel oil which led improved combustion. Fig (7) shows % brake power for tentative engine trials with used tested fuels (F5, F10, F20, and F30) and compare between the outcomes of a experiential trials and enhanced gasoline at the alike working conditions of the engine. Brake power is improved when speed of the engine raised [43], [74]–[76]. Brake power for pure gasoline (F0) is lower than that of enhanced gasoline and it improved by addition of fusel oil at all engine speeds. The best improvement of a brake power complete in speed (2700 rpm) by (F5).

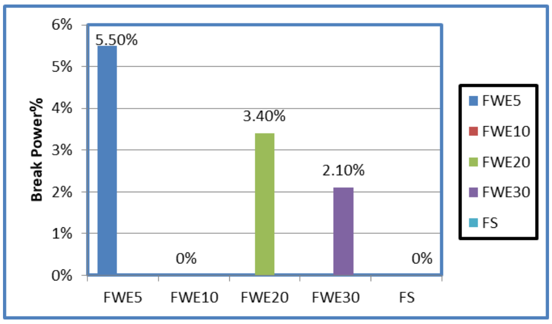

Figure 7. % BP change for tested fuel samples

Brake specific fuel consumption (BSFC). Variance in the (BSFC) for engine tested fuels comparative different the speed of engine in completely open choke (WOT). The relation of (BSFC) for totally tested fuels that used in tentative engine trials in speeds was higher. While engine effort in lower speed lead to an influence of weakly burning & refrigerating is vigorous that leads up to high scale of (BSFC) to completely tested fuel. By increase the speed of engine, (BSFC) decreases for lowest led to a slow improvement in burning process, so increasing the total energy operation (BSFC) initiates increase slowly when the speed of engine increases for totally tested fuels. Fig. (8) shows the reduced (BSFC) accomplished to (F5) in many speeds of engine compare by (FS). This improvement in (BSFC), because of the increase into energy density [77], and fusel oils higher octane number.

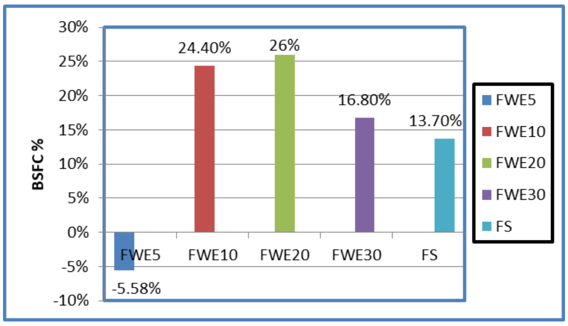

Figure 8. % BSFC change for tested fuel samples

Brake thermal efficiency. The BTE is ratio for a brake power formed of engine to complete thermal energy of a fuel [4][55]. BTE is a measure of estimation for engine process using tested fuels [53], [65], [66], [78]–[85]. Mono of presentation factors used for consider capacity of engine's for transform heat energy of the fuel for mechanical energy that higher assessment of engine performance of fuel consuming of diverse used fuels in tentative tests. Fig (9) shows %(BTE) changes at completely tested fuels that variation with use of fusel oil in tested . This rises in brake thermal efficiency is on reason of higher octane number for fusel oil, and its higher oxygen contains [86]–[91].

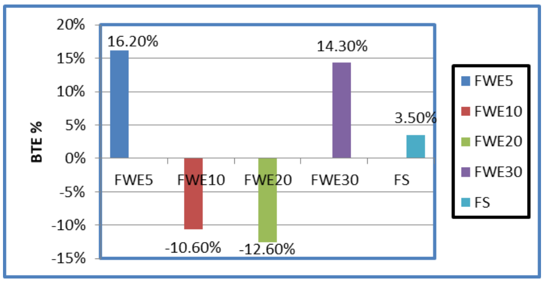

Figure 9. % BTE change for tested fuel samples

Conclusion

With this study, experimental research of an effect of a different proportion of (fusel oil & gasoline) mixtures were used as fuel for (SI) a spark-ignition engines, with different reaching for speeds of engine that was from (1500 - 2700) (rpm) with increasing of (300) (rpm), check valve opening 100% (WOT) under different act conditions. A pure gasoline fuel and tested mixtures properties (octane number , heating rate, density and viscosity), and engine performance (BP), (BSFC), (BTE), and engine exhaust emissions, were studied . Based on this work, most important conclusion summarized as following:

1 . Fusel oil adding to pure gasoline increase octane number & viscosity of tested fuels liken with a pure gasoline.

2 . Compare to pure gasoline, fuel mixtures (F5%, F10%, F20%, F30%) mixes improved engine power.

3 . The heating value for fusel oil was (30MJ/kg), after water elimination it raised to (33.8 MJ/kg), it was lesser than that of pure gasoline that (44.598 MJ/kg), so that lead to reduction heating value of tested fuel and an increase (SFC) by growing quantity of (fusel oil) into mixes, except fuel (F5) reduction BSFC at most speeds compare with the pure gasoline (F0).

4 . (BP) and (BTE) were raise with adding of (fusel oil) compare with a pure gasoline fuels.

Acknowledgments. Authors appreciate the technical support from the chemical and engine lab staf in the technical college of kirkuk.

Competing Interests

The authors declare that there are no competing interests.

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