jurnal 2

by Usbar Heat Release

Submission date: 15-Apr-2022 10:00PM (UTC+0700)
Submission ID: 1811447061
File name: 2._Jurnal_IJSBAR_Heat_Release_and....docx (396.46K)
Word count: 4511
Character count: 24424

International Journal of Sciences:
Basic and Applied Research
(IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Heat Release and Emission Analysis as an Indicator of Decreasing Cyclic Variation in Spark Ignition Engine Fueled by Gasoline Ethanol with Oxygenated Additive

Setia Abikusna[a*], Bambang Sugiarto[b], Iqbal Yamin[c]

[a]*Automotive Engineering, Astra Manufacturing Polytechnic, Jl. Gaya Motor Raya No. 8 Sunter 2, Jakarta, 14330, Indonesia*

[b,c]*Department of Mechanical Engineering, University of Indonesia, Kampus Baru UI Depok, Depok, 16424, Indonesia*

[a]*Email: setia.abikusna@gmail.com*

Abstract

As one component that may affect performance and emissions is that the cyclic variation if the cyclic variation is simply too large, the result's very influential on torque fluctuations which may reduce the engine driveability. This study examines the effect of gasoline bioethanol blends on a single-cylinder spark-ignition engine which is distributed by variations of fuels (E0, E5, E10, and E15) by adding 0.5 % vol/vol oxygenated cyclohexanol. The test results can improve COV_{IMEP} in the cycle to cycle variations so torque fluctuations are often minimized which ends in improved engine performance (heat release), besides that emissions become better.

Keywords: Ethanol fuel; performance; emission gas; coefficient of variation.

1. Introduction

Some internal ethanol characteristics cause the utilization of ethanol within the Otto engine to be better than gasoline. Ethanol incorporates a research amount of 108.6 and a motor octane of 89.7. This number (especially research octane) exceeds the most value which may be achieved by gasoline (even after adding certain additives to gasoline).

---

* Corresponding author.

Some properties of ethanol differ significantly from gasoline hydrocarbons like polar characters i.e., high affinity for water, unlike hydrocarbons, ethanol is extremely soluble with water [1, 15]. Therefore ethanol significantly increases water solubility in hydrocarbon fuels. this can be very useful and desirable (for example prevention of freezing of the fuel system), but the power to stay water-soluble in a very mixture of gasoline-ethanol is strongly influenced by temperature. A decrease in fuel temperature below a specific level causes the separation of the water phase. This leads to significant degradation of gasoline quality, a part of the oxygen content disappears, the octane value decreases and volatility changes. Thus the utilization of a combination of gasoline-ethanol can cause problems. The amount within the Otto engine's fuel shows its ability to avoid burning the air-fuel mixture prematurely (self-ignition). The burning of the air-fuel mixture within the Otto engine prematurely will cause the phenomenon of knocking (knocking) which has the potential to cut back engine power and might even cause serious damage to engine components. During now, the knock phenomenon limited the utilization of high compression ratios on gasoline engines. The high amount in ethanol allows the utilization of high compression ratios within the Otto engine. The correlation between efficiency and compression ratio has implications for the actual fact that the Otto engine with ethanol fuel (partially or wholly) incorporates a higher efficiency compared to gasoline fuel. Experimental research has been meted out to judge the consequences of ethanol and gasoline performance, emissions, and fuel combustion on fuel engine spots when operating with a skinny air-fuel mixture (lambda 0.9 - 1.6). Combustion parameters like combustion duration, ignition delay, temperature and pressure within the cylinder, and warmth release level are analyzed and accustomed to understanding fuel consumption behavior and emission of lean combustion mode compared to stoichiometric conditions. The experimental results show that combustion instability occurs after lambda 1.4. This causes a rise in fuel consumption. Instability is additionally because of a decrease in combustion temperature, with high heat release and low combustion temperatures in a very lean mixture. In general, ethanol produces greater combustion efficiency [2, 22, 23], besides the utilization of ethanol also can improve the emissions produced, directly proportional to the acceleration rate of the vehicle [3, 24]. Paper [4] tests independently using low-quality distilled bioethanol which utilizes waste heat in an exceedingly compact distillator to provide high-quality bioethanol ready to be used as a fuel mixture. From the test, it had been found that the wheel power and wheel torque produced from a combination of gasoline and bioethanol have a better value than pure gasoline fuel. The mixture of gasoline and bioethanol can increase power up to fifteen %. While the torque values produced within the mixture of E5, E10, and E 15 are 6.92 Nm, 6.64 Nm, and 6.92 Nm, respectively, where the worth is over pure gasoline at 6.1 Nm. Torque values were produced in an exceeding mixture of E5, E10, and E 15 with oxygenated additives respectively 7.5 Nm, 7.6 Nm, and 7.53 Nm [5]. The addition of oxygenated cyclohexanol generally can improve the performance (torque and power) produced by the fuel engine. Torque and brake power increase after engine rotation above 5,000 rpm. the best torque value is obtained from the variation of E10 ++ at 9.09 Nm at 6,000 rpm engine speed, 2.6 % over pure gasoline (E0). the foremost optimal power (brake power) is generated by a variable E15 of 6.84 kW at 8,000 rpm engine speed which increases 1.94 to stand proud of E0 [6]. Paper [7] conducted a comparative experiment, administrated at the injection port of an Internal Combustion Engine with ethanol hydro-fuel gasoline (E10W), ethanol gasoline (E10) and pure gasoline (E0). the results of engine load and also the addition of ethanol and air on combustion and emission characteristics are analyzed exhaustively. in step with experimental results, compared to E0, E10W shows higher results for cylinder inlet pressure at high loads. the utilization of E10W increases NOx emissions at high loads. However, at low loads, HC, CO, and CO_2 conditions are significantly reduced. E10W also produces less HC and CO, while CO_2 emissions aren't significantly affected in higher operations. Compared to E10, E10W shows higher leads to pressure and cylinder heat release rates under the operating conditions under test. Also, a discount in NOx emissions was observed for E10W from 5 nm to 100 nm, while HC, CO, and CO_2 were slightly higher in low and medium load conditions. From the results, it's going to be concluded that the E10W fuel could also be considered as a possible alternative fuel applied to Internal Combustion Engine. Paper [8] conducted experiments to attenuate cyclic variations on the SI engine, by controlling the spark timing for the entire cycle in an exceeding row. Used system identification techniques, a stochastic model was performed between spark timing and maximum cylinder pressure, a stochastic model was performed between spark timing and maximum cylinder pressure. the most cylinder pressure from the following cycle is estimated with this model. Control algorithms generated from LabView and installed into the sector Programmable Gate Array chassis. The test results, the most cylinder pressure of the following cycle may well be predicted quite well, and also the spark timing may well be adjusted to keep up the most cylinder pressure desired to cut back cyclic variations. within the fixed spark timing experiments, COV Pmax and COV imep were 3.764 and 0.677 %, while the results decreased to three.208 and 0.533 that when the GMV controller was applied. Paper [9] applies anhydrous ethanol to replace gasoline fuel which has shown benefits in terms of engine thermal efficiency, power output, and exhaust emissions from SI engines. Hydrous ethanol has also received more attention because of its energy and cost effectiveness. The main objective of this work is to minimize the amount of fuel injected into the engine's four-cylinder intake port at idle conditions. Engines with hydrous ethanol undergo lean-burn conditions and their combustion stability is analyzed. The coefficient of variation indicated the average effective pressure is an indicator for the stability of combustion with hydrocarbons and monitoring carbon monoxide emissions. Anhydrous ethanol burns faster than hydro ethanol in the fuel-air ratio under idle conditions. Burning leaner hydrous ethanol tends to increase the coefficient of variation in the average indicated effective pressure. Experimental results have found that the engine consumes 10 % greater hydrous ethanol based on mass compared to anhydrous ethanol. The main objective of this work is to explore the stability of burning hydrous ethanol when idling under lean conditions in SI engines. In-cylinder pressure according to the position of the crankshaft is measured and some combustion characteristics, e.g. heat release rate, fraction of the burned mass, and coefficient of variation are calculated by the first law of thermodynamics and discussed as a comparison with anhydrous ethanol and base gasoline. The aim of the experimental study is to use a mixture of gasoline-engine and anhydrous ethanol with the addition of cyclohexanol oxygenated additives which can reduce the coefficient of variation of the combustion cycle so that the engine driveability is increased as indicated by heat release and the resulting exhaust emissions.

2. Methods and Materials

The engine utilized in this study was the SI Honda type AFX12U21C07 single cylinder 125 cc SOHC with the electronically controlled mechanical system. General specifications of the test engine as in table 1.

The fuel used is 7 types of the gasoline-bioethanol mixture (E0, E5, E10, E15, E5++, E10++, and E15++) prepared based on variable mixing ratio form RON 88 to RON 96, ethanol quality by volume, with a mix of E5, E10, and E15, additionally because of the addition of cyclohexanol (C6H12O) additive with a composition of 0.5 % vol on each fuel mixture (E5++, E10++, and E15++).

Table 1: Test engine specifications

General Specifications	Parameter
Engine Type	4 stroke, SOHC, single-cylinder
Displacement	125 cc
Bore x stroke	52.4 mm x 57.9 mm
Compression ratio	9.3 : 1
Max Output	7.4 kW / 8,000 rpm
Max Torque	9.3 Nm / 4,000 rpm
Fuel System	Fuel Injection (PGM-FI)
Lubricant Capacity	0.7 L at periodic maintenance
Clutch type	Multiple wet Clutch with Coil Spring
Transmission type	4 Speed Manual, Rotary
Starter type	Electrical and Kick Starter

Table 2: Fuel types

Fuel Types	Gasoline	Ethanol	Additive
	% vol/vol		
E0	100	0	0
E5	95	5	0
E10	90	10	0
E15	85	15	0
E5++	95	4.5	0.5
E10++	90	9.5	0.5
E15++	85	14.5	0.5

Cyclohexanol is alcohol consisting of cyclohexane containing a single hydroxyl substituent, including into secondary alcohols, one of which functions as a solvent is produced industrially from phenol through hydrogenation in the presence of Ni/Al_2O_3 catalysts and from cyclohexane through oxidation with molecular oxygen Nano crystals (catalyst). The mixture is formed in the fuel tank and inlet manifold. So the level premix is high entirely and constant approximately. Therefore, mass flow rates can be measured and controlled at once. Testing the properties of fuel from various gasoline-bioethanol mixtures is carried out. Characteristics of gasoline and bioethanol are shown in table 3.

Cylinder combustion pressure is measured using a Kistler 6617B piezo-electric sensor (maximum pressure up to 200 bar) and recorded by the LabVIEW acquisition system. The crank position angle (up to 720 crank angle) is acquired with the shaft encoder; the sequence is adjusted to synchronize the cylinder combustion pressure signal with the crankshaft angle.

Table 3: Characteristics of gasoline and ethanol

Property	Ethanol	Gasoline
Chemical formula	C_2H_5OH	C5 – C11
Relative molecular mass	46	95 – 120
Density (kg/L)	0.79	0.700 - 0.750
Boiling point (^{0}C)	78.4	25 – 215
Flash point (^{0}C)	13	-40
Latent heat of vaporation (kJ/kg)	840	373
Stoichiometric heat of vaporation (kJ/kg)	93.9	25.8
Stoichiometric air-fuel ratio	8.95	14.7
Auto-ignition temperature (^{0}C)	363	300 – 400
HCV (MJ/kg)	26.9	42.9
Lower heating value (kJ/kg)	27,000	44,000
Mixture heating value (kJ/m^3)	3593	3750
RON	108	88
Laminar flame speed (m/s)	0.5	0.38

The temperature sensor unit with the K type thermocouple is employed to watch the temperature of the exhaust gas, fuel, lubricant, and electrical device. This machine is connected to the engine dynamometer for power, torque, and fuel consumption analysis, and is connected to the QROTECH-401 (4/5 gas analyzer) to live the content in exhaust gases such as Carbon Monoxide (CO), Carbon Dioxide (CO_2), and Hydrocarbons (HC). Analysis of the air-fuel ratio is operated by installing a lambda sensor (oxygen sensor) in the exhaust manifold. The following is an experimental set-up chart on a 125 cc SI engine connected to other supporting components (Fig.1). One of them is a pressure transducer that is directly attached to the spark plug.

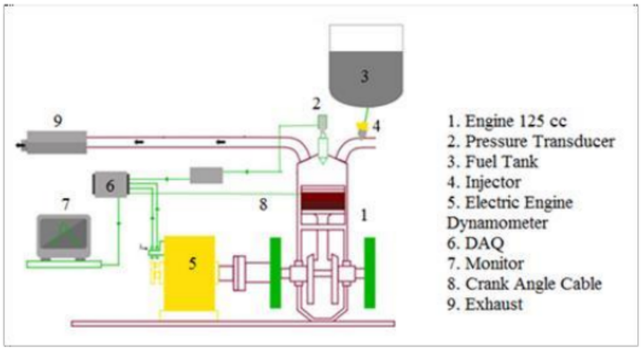


Figure 1: Experimental set up engine

3. Result and Discussion

3.1. Coefficient of Variations (COV)

Cycle to Cycle Variations (CCV) combustion in SI engines is an important subject that has been widely studied because it limits the engine operating range. Many researches have been done to observe the causes of cycle variations in the combustion process, leading to cycle variations in engine output performance. Cycle variations can be observed and characterized by the combustion pressure in the cylinder which is measured experimentally. Cylinder pressure produced from engine combustion is carried out from 4,000 rpm, 6,000 rpm and 8,500 rpm for each fuel mixture of E0, E5, E10, and E15. Each fuel mixture produces different combustion pressures in each cycle. When viewed from the graph at 8,500 rpm the least variation in combustion pressure occurs in the E5 mixture with a combustion pressure reaching 50 bar.

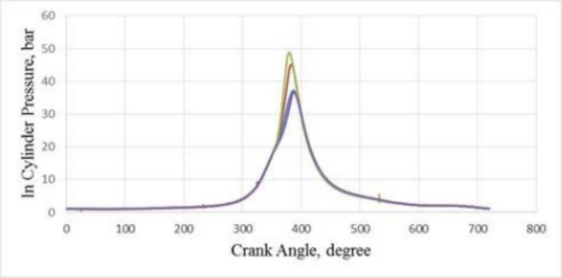


Figure 2: In-cylinder pressure vs. crank angle (E5)

The combustion pressure in the cylinder is an important indicator of cyclic variation, which is measured in each cycle at each rotation angle of the crankshaft. Some important parameters are associated with the pressure within the cylinder namely; the height pressure within the cylinder (Pmax), the crankshaft angle where the height pressure occurs (CA Pmax and the Indicated Mean Effective Pressure (IMEP) in one cycle. Engine performance is power and torque depending on IMEP, and variation in IMEP cause torque fluctuations.

$$\mathrm{COV}IMEP = \frac{\sigma IMEP}{IMEP}\ x100 \tag{1}$$

One important measure of cyclic variability is to measure the COV indicated mean effective pressure. The lowest $\mathrm{COV}_{\mathrm{IMEP}}$ produced from 800 cycles is within the fuel mixture E10++ which is 4.24 %, it defines the cyclic variability in indicated work per cycle, and it has have found that fluctuating torque (vehicle driveability) problems decrease because $\mathrm{COV}_{\mathrm{IMEP}}$ is less than about 10 %.

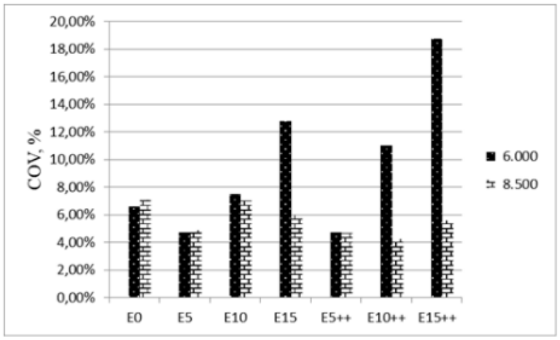


Figure 3: COV vs. fuel variations

3.2. Heat Release

The heat release rate is the heat value released per unit time in a sample due to an exothermic reaction after its activation energy is passed. This heat release rate is an important variable to describe the results of combustion. When analyzing internal combustion engines is done, cylinder pressure is always a significant experimental diagnostic because of its direct relationship with combustion and the processes that produce work. Cylinder pressure reflects the combustion process which involves the work of a piston produced by gas (due to changes in cylinder volume), heat transfer to the combustion chamber wall and mass flow in and out of the gaps between the piston, piston ring, and cylinder liner. Thus, to find out accurate results on how the combustion process spreads through the combustion chamber and each of these processes must be related to cylinder pressure [10, 14]. Calculation of heat release by cylinder pressure is intended to get some information about the combustion process in the engine. Heat release rate describes the performance of the engine under various operating conditions and the same engine performance under the same conditions. Also, both the physical and chemical properties of the fuel used in internal combustion engines are the main parameters that affect the heat release rate. At 4,000 rpm for the E10 ++ mixture, it was able to increase the largest heat release to 8.54 J/deg, while at the 6,000 rpm and 8,500 rpm rounds the largest heat release was still produced by the E10 ++ mixture at 8.04 J/deg and 8.01 J/deg, respectively . This shows that the addition of oxygenated additives to the mixture can increase heat release, one of the causes of this happening is the higher cyclohexanol density value (0.96 kg/L) than ethanol (0.79 kg/L) and from gasoline (0.7 - 0.75 kg/L) in order that at the same volume the amount of fuel will be heavier so the energy produced can be even greater.

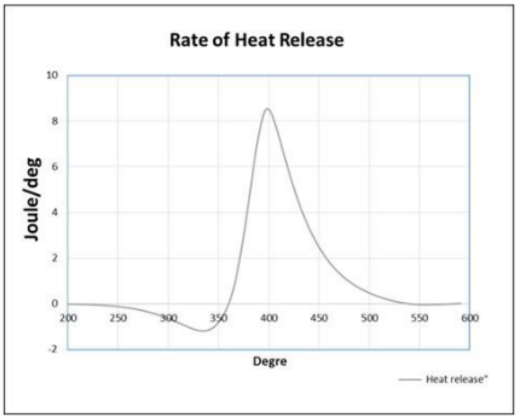
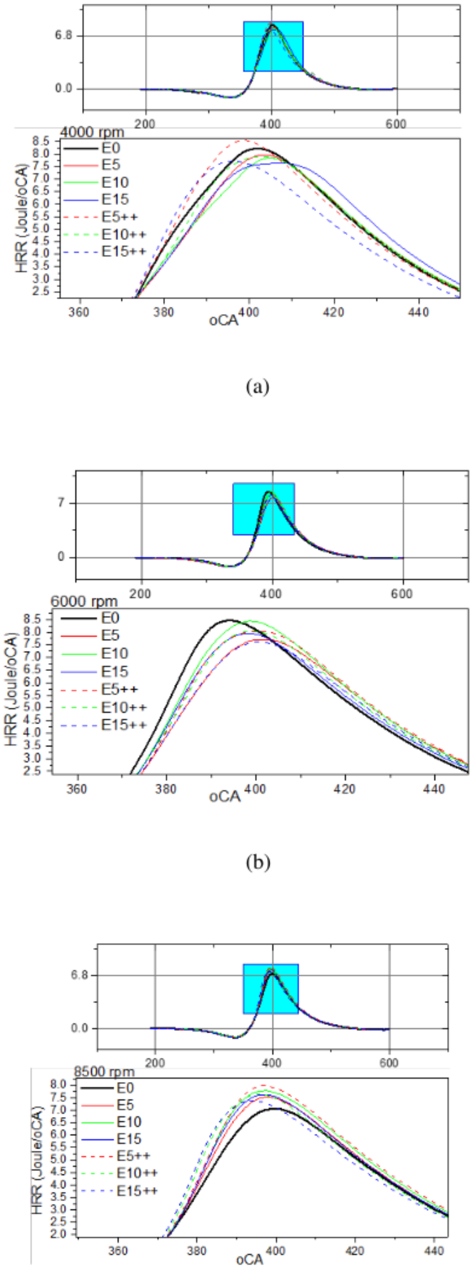


Figure 4: Rate of heat release (HRR)

The effect of the gasoline-ethanol with oxygenated additives blends on HRR is shown in Fig. 5. It can be seen that compared with pure gasoline, ethanol blend decreases HRR. In engine speed 4,000 rpm and 6,000 rpm, it can be seen that as ethanol concentration increase the HRR decrease. This is due to the properties of ethanol which have lower heating value than gasoline. When oxygenated additive added to gasoline-ethanol blend, it increases its maximum HRR, especially on fuel mixture E5. In engine speed 4,000 rpm, all fuel mixture with oxygenated additive has a higher and faster HRR. While in engine speed 6,000 rpm and 8,500 rpm, fuel mixture

E10 and E15 with additive have a lower and slower HRR.



(a)

(b)

(c)

Figure 5: Heat release rate in engine speed; 4,000 rpm (a), 6,000 rpm (b) and 8,500 rpm (c)

The greater total heat release indicates better combustion. Increasing the ethanol volume in the fuel mixture can increase the total heat release value. This is because ethanol has -OH molecules in its molecular group, which helps increase combustion, and the burning of large amounts of fuel occurs in areas close to TDC.

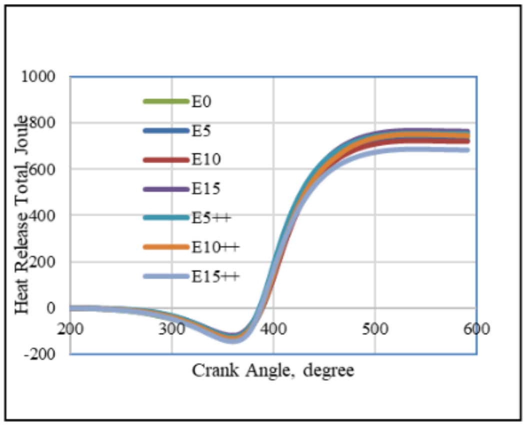


Figure 6: Total of heat release

For all fuels tested, heat release occurs in areas close to TDC [11]. The decrease in COV has a positive effect on the resulting heat release. This shows that adding cyclohexanol additive can improve the combustion process. As seen in Fig.7, the E5 ++ and E10 ++ heat release occured is higher than E5 and E10, even compared to the use of pure gasoline (E0) though.

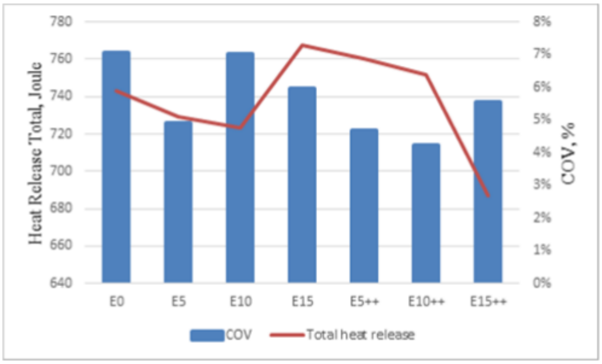


Figure 7: COV vs. total of heat release

The water content in the fuel can modify the engine power output in various ways, namely by reducing compression pressure, increasing the work done during the business steps to reduce temperatures that reduce heat loss, and increasing the rate of combustion. The water content slows down the combustion process but remains a constant amount of energy produced in each cycle [12]. In the fuel mixture E0 to E15, even though using ethanol fuel-grade which still has water content (0.5 %), can affect the combustion that occurs; therefore it affects the resulting heat release. By adding the cyclohexanol additive, which has the characteristic of a solvent due to its semi-polarity properties considering the longer C chain, this can make the ethanol-gasoline mixture more homogeneous and have an impact on the combustion that occurs, which is in turn substantially affects the total heat release produced as shown in Fig. 7.

3.3. Emission

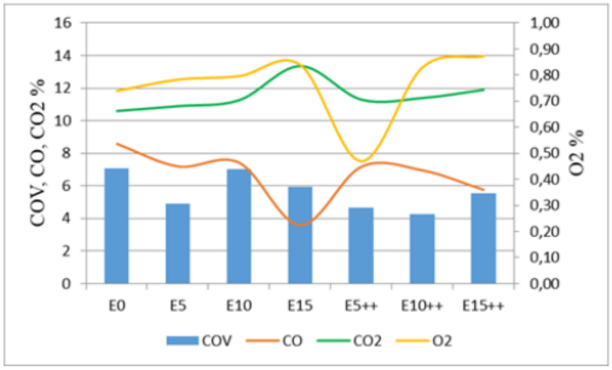


Figure 8: COV vs. CO, CO_2, and O_2

In the emissions analysis section, Fig.8 above can show the effect of COV from each fuel mixture on the variation of engine speed on CO, CO_2, and O_2 produced. The results of CO gas with the addition of additive resulted in comparison with other fuel variations, as shown above. The addition of an additive to variations in fuel with the percentage of ethanol can reduce CO gas emissions produced. The effect of adding ethanol on emissions of additive CO and non-additive CO, this is a product of incomplete combustion because there is inadequate oxygen in the air-fuel mixture or insufficient combustion time in one cycle. The concentration of CO emissions is also very dependent on engine operating conditions and the air-fuel ratio. Some CO always appears on the exhaust even in the thin mixture, but the concentration decreases with decreasing combustion temperature. The O_2 concentration in the combustion exhaust gas is inversely proportional to the concentration of CO_2 produced. CO and CO_2 levels have a closely linked. Decreased CO levels in exhaust gas emissions will increase CO_2 levels. CO_2 is a component of the product in the combustion reaction. Burning carbon that forms CO_2 will produce more heat per unit of fuel (8,084 kcal/kg of carbon) than producing CO (2,430 kcal/kg of carbon). The purpose of complete combustion is to release all the heat contained in the fuel. In other words, CO_2 is the desired gas as a product of combustion reaction, where for the optimum fuel oil must produce CO_2 as much as 14.5% to 15%. It can also be seen that the levels of O_2 produced with a mixture of ethanol added with additives on average have increased although not significantly. This is because the combustion process that occurs requires a large O_2 so that O_2 that comes out as flue gas from the mixture with additives the amount is not too significant. O_2 concentration in the combustion exhaust gas is inversely proportional to the concentration of CO_2 produced.

The addition of ethanol gives a change in the exhaust emissions of HC, one of the possible factors is wall quenching, which is when the fire spreads towards the wall, there is a thin layer that does not occur chemical reactions except the occurrence of fuel breakdown.

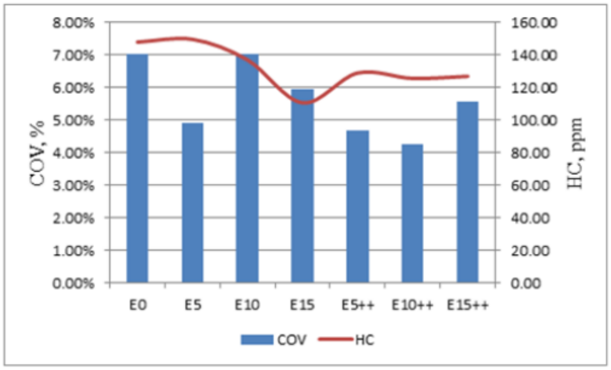


Figure 9: COV vs. HC

This thin layer contains unburnt HC or also called quench distance. The magnitude of this quench distance varies between 0.008 cm to 0.038 cm which is affected by the mixture temperature, pressure, AFR, wall surface temperature and combustion deposits. The amount of HC concentration in the exhaust gas is equal to the concentration of CO, which is high when the mixture is rich and decreases at the highest temperature point. Ethanol has a shorter quenching distance compared to gasoline so that the fire from burning the mixture of gasoline and ethanol can propagate closer to the cylinder wall. This indicates that the amount of fuel burned is increasing, thereby reducing HC which is a component of fuel oil. On the other hand carbon content (50.59 %) and hydrogen (12.98 %) are still lower than gasoline, this also greatly helps reduce HC levels that do not burn. Besides the air-fuel mixing process increases the intensity of turbulence at higher engine speeds, this causes more complete combustion so it can also reduce HC. HC concentration is also closely related to combustion chamber design, induction system design and operating speed and load variables.

4. Conclusions

The effect of the addition of ethanol to gasoline used as a fuel mixture on the 125 cc SI injection engine has a positive effect on the lower cyclic variable (CCV), especially heat release (up 3 %), as well as on the exhaust emissions such as CO levels (down 58 %), CO2 (up 26 %), O2 (up 14 %), and HC (down 25 %). By increasing ethanol content, CCV is getting lower, performance is increasing, and emissions are also getting better. Cyclohexanol oxygenated additive with C6 carbon chain, where the longer carbon chain makes the substance more non-polar (low water solubility), this can make the mixture of gasoline (non-polar) and ethanol (polar) can be mixed increasingly homogeneous, therefore more complete combustion, as evidenced by the effect that occurs is the lower COV coupled with the increasing total heat relation (at E5++ and E10 ++).

Acknowledgements

The authors would like to thank DRPM UI for providing the grant TADOK 2019 in this research, so that it can

be completed well.

References

[1]. Zlata Mujikova, Milan Pospisil, Jaroslac Cerny. "Water tolerance of petrol-ethanol blends," in: Preliminary Communication University of Chemistry and Technology, Prague, 2016.

[2]. Vinícius Rückert Roso, Nathalia Duarte Souza, Carlos Eduardo. "Effects of mixture enleanment in combustion and emission parameters using a flex-fuel engine with ethanol and gasoline." Applied Thermal Engineering, 153, pp. 463-472, 2019.

[3]. Policarpo, N.A., F.S. Frutuoso, D.R. Cassiano. "Emission estimates for an on-road flex-fuel vehicles operated by ethanol-gasoline blends in an urban region Brazil." Elsevier Urban Climate, 24, pp. 111-120, 2018.

[4]. Setia Abikusna, Bambang Sugiarto, Dedi Suntoro, Azami. "Low grade bioethanol for fuel mixing on gasoline engine using distillation process," in AIP Conference Proceedings, 2017, 1826,20019/doi.org/10.1063/1.4979235.

[5]. Setia Abikusna, Bambang Sugiarto, Ratna Monasari. "Performance analysis (WHP and torque) on SI engine fueled with low grade bioethanol and oxygenated fuel additive," in IOP Conference Series: Earth and Environmental Science, 2018, 105,012057/doi.org/10.1088/1755-1315/105/1/012057.

[6]. Setia Abikusna, Bambang Sugiarto, Ratna Monasari, Iqbal Yamin. "The effect of additive on combustion characteristics and cycle to cycle variations on SI engine fueled by gasoline and bioethanol." Eastern European Journal of Enterprise Technologies, 6/6 (96), 2018.

[7]. Wang X., Chen Z., Ni J., Liu S., Zhou H. "The effects of hydrous ethanol gasoline on combustion and emission characteristics of a port injection gasoline engine," case studies in Thermal Engineering, vol.6, pp. 147–154, 2015, doi: https://doi.org/ 10.1016/j.csite.2015.09.007.

[8]. Kaleli, A., M.A. Ceviz, and K. Erenturk. "Controlling spark timing for consecutive cycles to reduce the cyclic variations of SI engines." Applied Thermal Engineering, 87, pp. 624-632, 2015.

[9]. Sathaporn Chuepeng, Sudecha Srisuwan, Manida Tongroon. "Lean hydrous and anhydrous bioethanol combustion in spark ignition engine at idle." Energy Conversion and Management, 128, pp. 1-11, 2016.

[10]. Heywood, John B. Internal combustion engine fundamentals. McGraw-Hill Series in Mechanical Engineering: ISBN 0-07-028637-X, 1988.

[11]. Vighnesha Nayak, Rashmi G.S., Parashuram Citragar. "Combustion characteristics and cyclic variation of a LPG fuelled MPFI four cylinder gasoline engine." Energy Procedia, 90, pp. 470-480, 2016.

[12]. Schifter, I., L. Diaz, J.P. Gomez. "Combustion characterization in a single cylinder engine with mid-levels hydrated ethanol–gasoline blended fuels." Fuel, 103, pp. 292-298, 2013.

[13]. Phuangwongtrakul, S., W. Wechsatol, T. Sethaput. "Experimental study on sparking ignition engine performance for optimal mixing ratio of ethanol–gasoline blended fuels." Applied Thermal Engineering, 100, pp. 869-879, 2016.

[14]. Sen, A. K., A. Medina, P. L. Curto-Risso, A. Calvo Herna´ndez. "Effect of ethanol addition on cyclic variability in a simulated spark ignition gasoline engine." Springer Science & Business, Meccanica, 49,

pp. 2285-2297, 2014.

[15]. Charles E. Wyman. Handbook on bioethanol: production and utilization. Applied Energy Technology Series, 2010.

[16]. Zhuang, Y. and G. Hong. “Effects of direct injection timing of ethanol fuel on engine knock and lean burn in a port injection gasoline engine.” Fuel, 135, pp. 27-37, 2014.

[17]. Yao, Y.-C., J.-H. Tsai, and I.T. Wang. “Emissions of gaseous pollutant from motorcycle powered by ethanol–gasoline blend.” Applied Energy, 102, pp. 93-100, 2013.

[18]. Turkcan, A., A.N. Ozsezen, and M. Canakci. “Experimental investigation of the effects of different injection parameters on a direct injection HCCI engine fueled with alcohol–gasoline fuel blends.” Fuel Processing Technology, 126, pp. 487-496, 2014.

[19]. Zhuang, Y. and G. Hong. “Primary investigation to leveraging effect of using ethanol fuel on reducing gasoline fuel consumption.” Fuel, 105, pp. 425-431, 2013.

[20]. Anand, T.N.C., A. Madan Mohan, and R.V. Ravikrishna. “Spray characterization of gasoline-ethanol blends from a multi-hole port fuel injector.” Fuel, 102, pp. 613-623, 2012.

[21]. Catapano, F., P. Sementa, and B.M. Vaglieco. “Air-fuel mixing and combustion behavior of gasoline-ethanol blends in a GDI wall-guided turbocharged multi-cylinder optical engine.” Renewable Energy, 96, pp. 319-332, 2016.

[22]. Costa, R.C. and J.R. Sodré. “Compression ratio effects on an ethanol/gasoline fuelled engine performance.” Applied Thermal Engineering, 31(2), pp. 278-283, 2011.

[23]. Sileghem, L., T. Wallner, and S. Verhelst. “A quasi-dimensional model for SI engines fueled with gasoline–alcohol blends: knock modeling.” Fuel, 140, pp. 217-226, 2015.

[24]. Melo, T.C.C.d., et al. “Hydrous ethanol–gasoline blends–combustion and emission investigations on a flex-fuel engine.” Fuel, 97, pp. 796-804, 2012.

jurnal 2

ORIGINALITY REPORT

19%	12%	17%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Sathaporn Chuepeng, Sudecha Srisuwan, Manida Tongroon. "Lean hydrous and anhydrous bioethanol combustion in spark ignition engine at idle", Energy Conversion and Management, 2016 Publication	3%
2	cyberleninka.org Internet Source	2%
3	Alirıza Kaleli, Mehmet Akif Ceviz, Köksal Erenturk. "Controlling spark timing for consecutive cycles to reduce the cyclic variations of SI engines", Applied Thermal Engineering, 2015 Publication	2%
4	idr.l2.nitk.ac.in Internet Source	1%
5	www.grin.com Internet Source	1%
6	Hui Liu, Zhi Wang, Yan Long, Shouzhi Xiang, Jianxin Wang, Scott W. Wagnon. "Methanol-	1%

gasoline Dual-fuel Spark Ignition (DFSI) combustion with dual-injection for engine particle number (PN) reduction and fuel economy improvement", Energy, 2015
Publication

7	www.praiseworthyprize.org Internet Source	1 %
8	www.tandfonline.com Internet Source	1 %
9	yamaha.padgettsmotorcycles.com Internet Source	<1 %
10	Amit Kumar Thakur, Ajay Kumar Kaviti. "Progress in regulated emissions of ethanol-gasoline blends from a spark ignition engine", Biofuels, 2018 Publication	<1 %
11	Phuangwongtrakul, S., W. Wechsatol, T. Sethaput, K. Suktang, and S. Wongwises. "Experimental study on sparking ignition engine performance for optimal mixing ratio of ethanol–gasoline blended fuels", Applied Thermal Engineering, 2016. Publication	<1 %
12	ageng.asu.lt Internet Source	<1 %
13	opus.lib.uts.edu.au Internet Source	<1 %

14	docs.lib.purdue.edu Internet Source	<1 %
15	Aniket P. Kulkarni, Devendra Deshmukh. "SPATIAL DROP-SIZING IN AIRBLAST ATOMIZATION-AN EXPERIMENTAL STUDY", Atomization and Sprays, 2017 Publication	<1 %
16	Hassan A. Aljaberi, A. Aziz Hairuddin, Nuraini Abdul Aziz. "Effect of Fuel Injection Strategies on Performance and Emissions in HCCI Engines: a Review", International Review of Mechanical Engineering (IREME), 2018 Publication	<1 %
17	Shun-Liang Ding, En-Zhe Song, Li-Ping Yang, Grzegorz Litak, Chong Yao, Xiu-Zhen Ma. "Investigation on nonlinear dynamic characteristics of combustion instability in the lean-burn premixed natural gas engine", Chaos, Solitons & Fractals, 2016 Publication	<1 %
18	"Vehicle and Automotive Engineering 2", Springer Science and Business Media LLC, 2018 Publication	<1 %
19	hdl.handle.net Internet Source	<1 %
20	onlinelibrary.wiley.com	

Internet Source

<1%

---

21 thermalscience.vinca.rs

Internet Source

<1%

---

22 www.undp.ps

Internet Source

<1%

---

23 Liu, Hui, Zhi Wang, Yan Long, and Jianxin Wang. "Dual-Fuel Spark Ignition (DFSI) combustion fuelled with different alcohols and gasoline for fuel efficiency", Fuel, 2015.

Publication

<1%

---

24 jurnal.polibatam.ac.id

Internet Source

<1%

---

25 www.e-motom.gr

Internet Source

<1%

---

26 C. Ananda Srinivasan, C. G. Saravanan, M. Gopalakrishnan. "Emission reduction on ethanol–gasoline blend using cerium oxide nanoparticles as fuel additive", Particulate Science and Technology, 2017

Publication

<1%

---

27 Prakhar Chansauria, R.K. Mandloi. "Effects of Ethanol Blends on Performance of Spark Ignition Engine-A Review", Materials Today: Proceedings, 2018

Publication

<1%

28	docplayer.net Internet Source	<1 %
29	eprints.nottingham.ac.uk Internet Source	<1 %
30	idr.nitk.ac.in Internet Source	<1 %
31	journal.ump.edu.my Internet Source	<1 %
32	repository.kaust.edu.sa Internet Source	<1 %
33	www.vehicular.isy.liu.se Internet Source	<1 %
34	I Made Suarta, I Nyoman Gede Baliarta, I.P.G. Sopan Rahtika, Putu Wijaya Sunu. "The Role of Hydrogen Bonds Of The Azeotropic Hydrous Ethanol Fuel Composition To The Exhaust Emissions", Journal of Physics: Conference Series, 2018 Publication	<1 %
35	jurnal.untag-sby.ac.id Internet Source	<1 %
36	onepetro.org Internet Source	<1 %
37	Chondanai Vipavanich, Sathaporn Chuepeng, Sompol Skullong. "Heat release analysis and	<1 %

thermal efficiency of a single cylinder diesel dual fuel engine with gasoline port injection", Case Studies in Thermal Engineering, 2018
Publication

---

38 Marthen E. N. Paloboran, I. Nyoman Sutantra, Bambang Sudarmanta. "Performances and Emissions Characteristics of Three Main Types Composition of Gasoline-Ethanol Blended in Spark Ignition Engines", International Review of Mechanical Engineering (IREME), 2016
Publication
<1%

---

39 Seyfi Polat. "An experimental study on combustion, engine performance and exhaust emissions in a HCCI engine fuelled with diethyl ether–ethanol fuel blends", Fuel Processing Technology, 2016
Publication
<1%

---

40 Tian, Guangdong, Tiangang Qiang, Jiangwei Chu, and Guangming Qiao. "Condensation Dripping Water Detection and Its Control Method from Exhaust Pipe of Gasohol Vehicle under Low Environmental Temperature Conditions: A Case Study in Harbin, China", Advances in Mechanical Engineering, 2012.
Publication
<1%

---

41 es.scribd.com
Internet Source
<1%

42	A. K. Sen, A. Medina, P. L. Curto-Risso, A. Calvo Hernández. "Effect of ethanol addition on cyclic variability in a simulated spark ignition gasoline engine", Meccanica, 2014 Publication	<1 %
43	B.M. Masum, H.H. Masjuki, M.A. Kalam, I.M. Rizwanul Fattah, S.M. Palash, M.J. Abedin. "Effect of ethanol–gasoline blend on NOx emission in SI engine", Renewable and Sustainable Energy Reviews, 2013 Publication	<1 %
44	Miguel Humberto Barrientos Sandoval, Carlos Eduardo Castilla Alvarez, Vinícius Rückert Roso, Nathália Duarte Souza Alvarenga Santos et al. "The influence of volume variation in a homogeneous prechamber ignition system in combustion characteristics and exhaust emissions", Journal of the Brazilian Society of Mechanical Sciences and Engineering, 2020 Publication	<1 %
45	www.ijee.net Internet Source	<1 %
46	Irina Ayelén Jiménez. "Development of Combustion Indicators for Control of Multi-Fuel Engines Based on New Combustion Concepts", Universitat Politecnica de Valencia, 2022	<1 %

Publication

---

47 Thakur, Amit Kumar, Ajay Kumar Kaviti, Roopesh Mehra, and K.K.S. Mer. "Progress in performance analysis of ethanol-gasoline blends on SI engine", Renewable and Sustainable Energy Reviews, 2017. <1%

Publication

---

48 s3-eu-west-1.amazonaws.com <1%

Internet Source

Exclude quotes	On	Exclude matches	< 5 words
Exclude bibliography	Off		