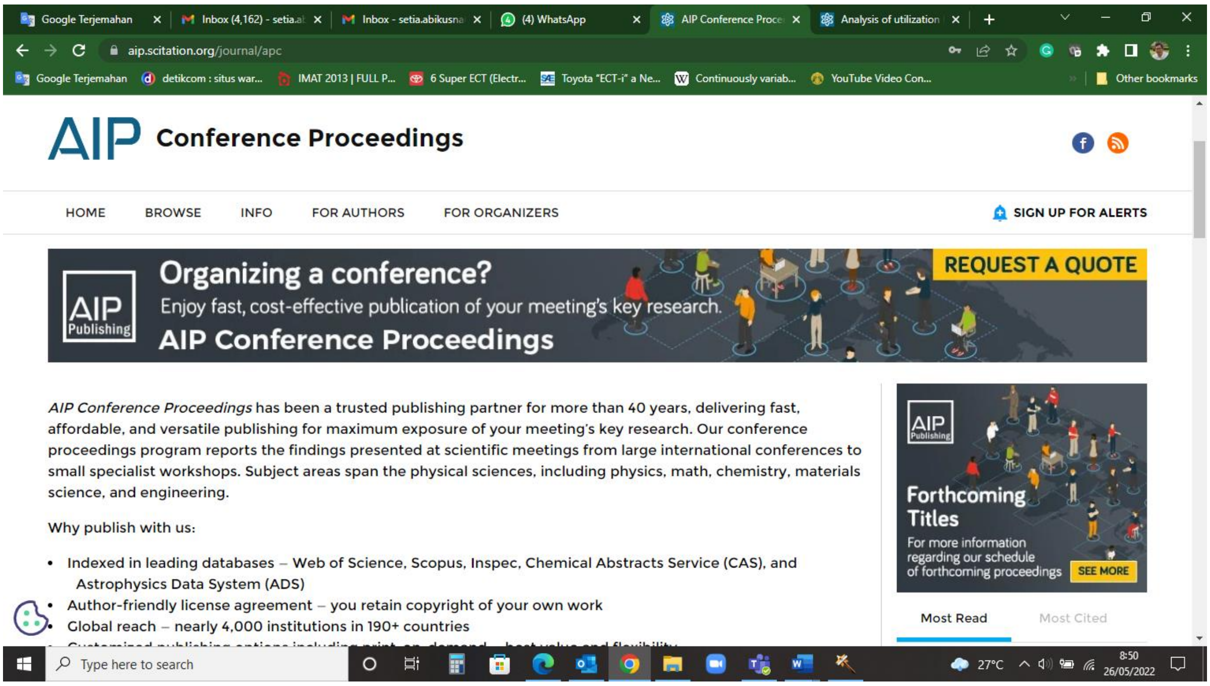

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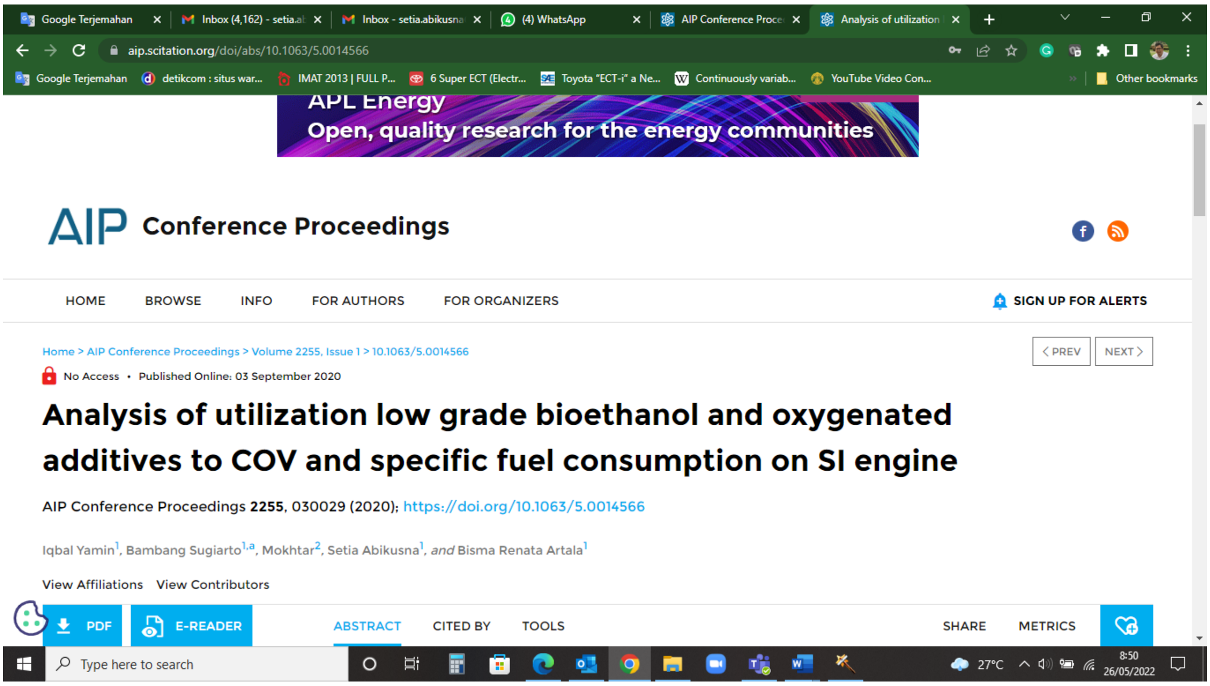

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Analysis of utilization low grade bioethanol and oxygenated additives to COV and specific fuel consumption on SI engine

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Analysis of utilization Low Grade Bioethanol and Oxygenated Additives to COV and Specific Fuel Consumption on SI Engine

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Abstract. To facilitate the activities of Indonesians, government issues many public transportations, furthermore a lot of Indonesians uses their own private vehicle as well. Unfortunately, all of these transportations still utilize fossil fuel as energy sources. And with the increasing number of populations, the number of transportations also rises. This condition shows that Indonesia is still dependent on non-renewable energy sources. One alternative energy currently being developed as an alternative fuel in motorized vehicles is bioethanol. The addition of bioethanol to gasoline will certainly change the fuel properties, the fuel will be more difficult to self-ignite so the pressure generated in the combustion chamber will be more consistent. Coefficient of variation (COV) represent the ratio of the standard deviation to the mean of a set of data, in this study in cylinder pressure data (IMEP) is used. Based on previous research that discussed the analysis of emission gas and fuel consumption on SI engine fueled with low-grade bioethanol and oxygenated additive, the authors examined further to analyze the characteristic of ethanol blend and oxygenated additive to COV_{IMEP} and Specific Fuel Consumption (SFC) of various fuel mixture as well as COV_{IMEP} correlation with SFC at variable engine speed were investigated. The result of study shows that ethanol blend and oxygenated additives in gasoline decrease variation in combustion pressure occurrences, lower COV. Ethanol – gasoline blend increased SFC compared with pure gasoline, while ethanol – gasoline blend with additive slightly reduce SFC compared with their own respective mixture.

INTRODUCTION

To facilitate the activities of Indonesians, government issues many public transportations, such as online transportations, taxi bikes, public minivan, buses, taxis, trains, and MRT. Furthermore, a lot of Indonesians uses their own private vehicle as well. Unfortunately, all of these transportations still utilize fossil fuel as energy sources. And with the increasing number of populations, the number of transportations also rises. We can see that the growth of motor vehicles over the past five years has reached 8.63% per year [1], thus the use of fuels also increases over the years. This condition shows that Indonesia is still dependent on non-renewable energy sources. One alternative energy currently being developed as an alternative fuel in motorized vehicles is bioethanol. The addition of bioethanol to gasoline will certainly change the fuel properties, the fuel will be more difficult to self-ignite [2] so the pressure generated in the combustion chamber will be more consistent. Coefficient of variation (COV) represent the ratio of the standard deviation to the mean of a set of data [3], in this study in cylinder pressure data (IMEP) is used.

Palmer, FH [4] reported that during low speed acceleration, oxygenated fuel blend gave a better anti-knock performance than hydrocarbon fuel of similar octane range. Saikrishnan, V et al [5] . Performance tests were conducted for the three blends E5, E10, E15 as well as E0 (100 % gasoline). The results showed that blends of gasoline and ethanol increased the brake power, brake thermal efficiency and the fuel consumption.

In the previous research, distillation of low grade bioethanol with compact distillator were experimented [6] up to the analysis of emission gas and fuel consumption on SI engine fueled with low-grade bioethanol and oxygenated additive was discussed [7]. In this research, the authors examined further to analyze the characteristic of ethanol blend and oxygenated additive to COV_{IMEP} and Specific Fuel Consumption (SFC) of various fuel mixture as well as COV_{IMEP} correlation with SFC at variable engine speed were investigated.

COEFFICIENT OF VARIATIONS

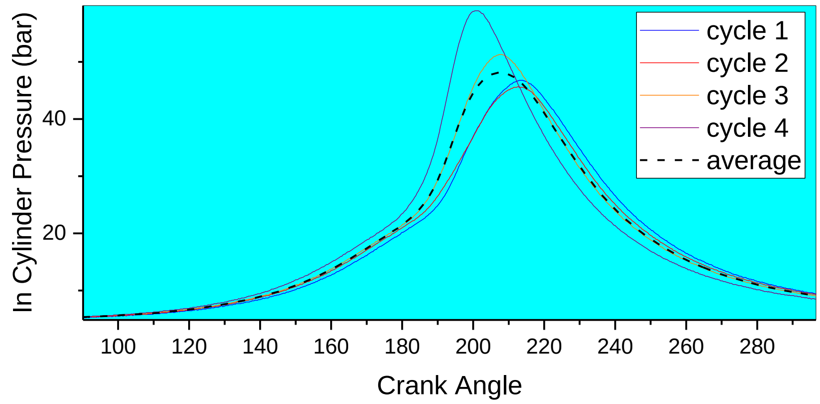


FIGURE 1. Crank Angle vs Cylinder Pressure

Figure 1 show a curve of cylinder pressure against the rotation of crank angle in 4 consecutive cycle, it shows that maximum pressure for every cycle is different. The reason for this is that there is a possibility that the fuel in the cylinder does not burn at the same level. Using statistical method coefficient of variations (COV) to represent the ratio of the standard deviation to the mean of a set of data, combustion process of every cycle can be analyzed with a variation of data in cylinder pressure (IMEP) experimented. Indicative Mean Effective Pressure (IMEP) and Pmax are important parameters and are commonly used as a measure of cyclic variation [8]. It should be noted that Pmax is also a feedback signal in a closed loop control system.

$$COV = \frac{\sigma IMEP}{\mu IMEP} \times 100 \quad (1)$$

The standard deviation (σ) is the square root of the average arithmetic of the square of the deviation from the mean (μ), and the variance (σ2) is the square of the standard deviation. Coefficient of variance (COV) is defined as the ratio of the standard deviation to the mean value. To produce the effect of cyclic variation in combustion, work only given to piston during the compression and expansion steps, therefore COV is calculated as the standard deviation of the IMEP calculated between the closure of the intake valve and the opening of the exhaust valve, divided by average IMEP and is usually expressed in percent.

EXPERIMENTAL METHOD

The engine used in this study is spark ignition (SI) engine single cylinder 125 cc single overhead camshaft (SOHC) with electronically controlled fuel injection system. General specification of the test engine can be seen in Table 1.

TABLE 1. General Specification of test Engine

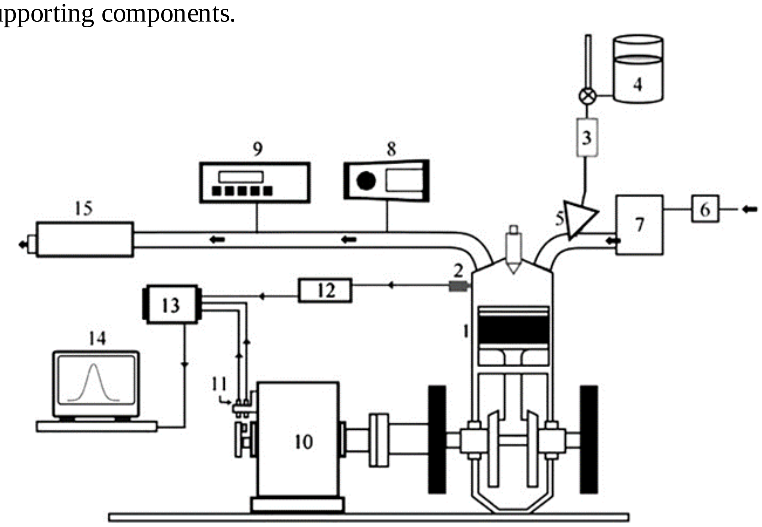
General Specification	Parameter
Engine type	4 stroke, SOHC, single cylinder
Displacement	125 cc
Bore x stroke	52.4 mm x 57.9 mm
Compression ratio	9.3:1
Max output	7.4 kW / 8000 RPM
Max torque	9.3 Nm / 4000 RPM
Fuel system	Fuel injection (PGM-FI)

The fuel used is 7 types of the gasoline-bioethanol mixture prepared based on variable mixing ratio from RON 88, ethanol quality by volume, with a mixture of E5, E10, and E15, as well as the addition of oxygenated additive cyclohexanol (C6H12O) with a composition of 0.5 % on each fuel mixture (E5++, E10++, E15++). The mixture is formed in the fuel tank and inlet manifold. So, the level premix is quite high and almost constant. Therefore, mass flow rates can be measured and controlled at once. Testing the properties of fuel from various gasoline-bioethanol mixtures is carried out. The results of testing various fuels are as shown in Table 2.

TABLE 2. Fuel Characteristic Test

Parameter		E0	E5	E10	E15	Method
RON		87.9	90.5	93.6	96.5	ASTM D 2699
Oxygen content	%m/m	0	1.8	4	5.9	ASTM D 4815
Vapor pressure	kPa	48.6	38.8	68.7	65.8	ASTM D 323
Specific gravity on 15 ºC	kg/m^3	718.4	728.1	745.8	748.7	ASTM D 4052

Cylinder combustion pressure is measured using a Kistler 6617B piezo-electric sensor (maximum pressure up to 200 bars) and recorded by the LabVIEW acquisition system. The crank position angle (up to 720 crank angles) is acquired with the shaft encoder; the sequence is adjusted to synchronize the cylinder combustion pressure signal with the crankshaft angle. The temperature sensor unit with the K type thermocouple is used to monitor the temperature of the exhaust gas, fuel, lubricant, and spark plug. 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 measure the content in exhaust gases such as Carbon Monoxide (CO), Carbon Dioxide (CO_2), Hydrocarbons (HC), and excess air (O_2). Analysis of the air-fuel ratio is done by installing a lambda sensor (oxygen sensor) in the exhaust manifold. Figure 2 is an experimental set-up chart on a 125 cc SI engine connected to other supporting components.



1. Test Engine
2. Pressure Transducer
3. Gasoline Pump
4. Gasoline Tank
5. Injector
6. Air Filter
7. Air Stabilizing Tank
8. Smoke Meter
9. Gas Analyzer
10. Eddy Current Dyno
11. CAD Encoder
12. Amplifier
13. DAQ
14. Monitor
15. Exhaust

FIGURE 2. Experimental Set-up SI Engines

This experimental test is carried out after running the engine until it reached a steady state, where the oil and cooling water temperatures were at 50 ºC. The throttle valve opening is maintained at 100%, and the ignition timing is controlled according to the ignition system in the fuel injection control. As for engine speed variations at 4,000 rpm up to 8,500 rpm with engine speed increases every 500 rpm. This engine speed variation is to see conditions from low, medium, to high speed.

RESULT AND DISCUSSION

The characteristic of ethanol blend and oxygenated additive to COV_{IMEP} and specific fuel consumption of various fuel mixture as well as COV_{IMEP} correlation with SFC at variable engine speed were investigated.

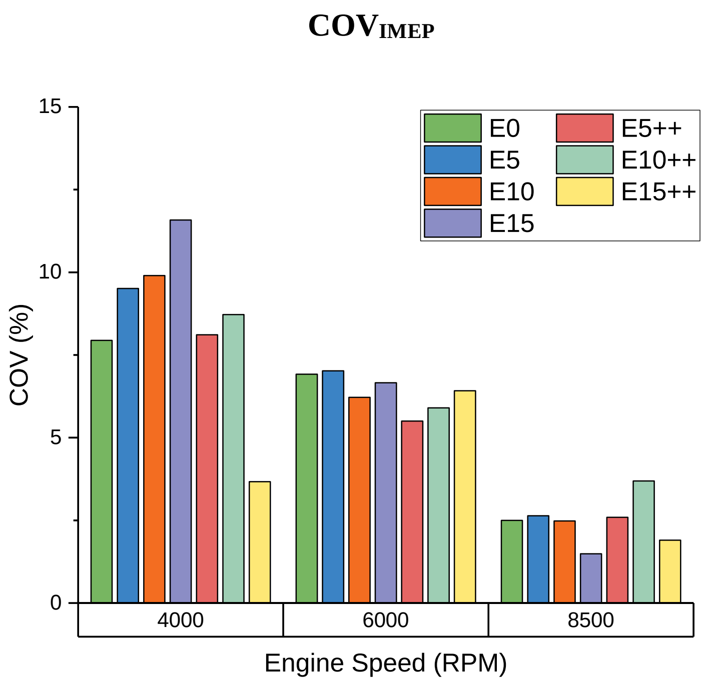


FIGURE 3. COV vs Engine Speed

COV_{IMEP} from an experimental test for every fuel mixture on engine speed 4000, 6000 and 8500 RPM can be seen in Fig. 3. Figure 3 show that additions of oxygenated additive on E15 fuel mixture can decrease COV in engine speed 4000 rpm with value 3.67%, decreased 4.27% compared to E0. And in engine speed 6000 rpm, additions of oxygenated additive on E5 fuel mixture decreases COV 1.42% compared to E0. While in engine speed 8500 rpm on E15 fuel mixture, it decreases COV 1.01% compared to E0. Lower COV value indicate that the least variation in combustion pressure occurs.

SFC

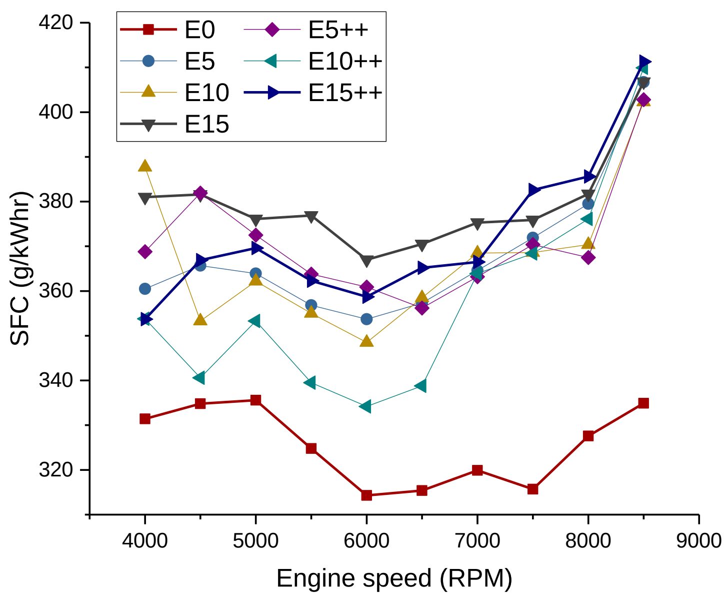


Figure 4. SFC vs Engine Speed

The effect of the gasoline-ethanol with oxygenated additive blends on SFC is shown on Fig. 4. It can be seen that compared with pure gasoline; ethanol blend increases SFC as ethanol concentration increased, with 15% ethanol blend SFC increases 52.7 g/kWh in engine speed 6000 rpm. This is due to the higher density of ethanol so the amount of fuel per volume increased. The addition of oxygenated additive to gasoline-ethanol blend decreases SFC compared with their own respective mixture without additive. Compared to the mixture without additive, additions of oxygenated additive to E10 and E15 decreases SFC 33.8 and 27.3 g/kWh in engine speed 4000 rpm. And in engine speed 6000 rpm, gasoline-ethanol blend with additive decreases SFC for E10 and E15, 14.3 g/kWh and 8.3 g/kWh. This is due to the oxygen content in the additive, so the combustion process improved which means more power.

COV VS SFC

The correlations between COV and SFC can be seen in Fig. 5. In engine speed 4000 rpm and 6000 rpm, compared with pure gasoline; ethanol blend increases COV value, it can be seen that as COV value increase the SFC increases too. Whereas gasoline-ethanol blend with additive, compared with gasoline-ethanol blend decreases the COV value; and as COV value decreases the SFC decreases too. It shows that lower COV value indicate that the least variation in combustion pressure occurs so the combustion process improved and SFC decreased.

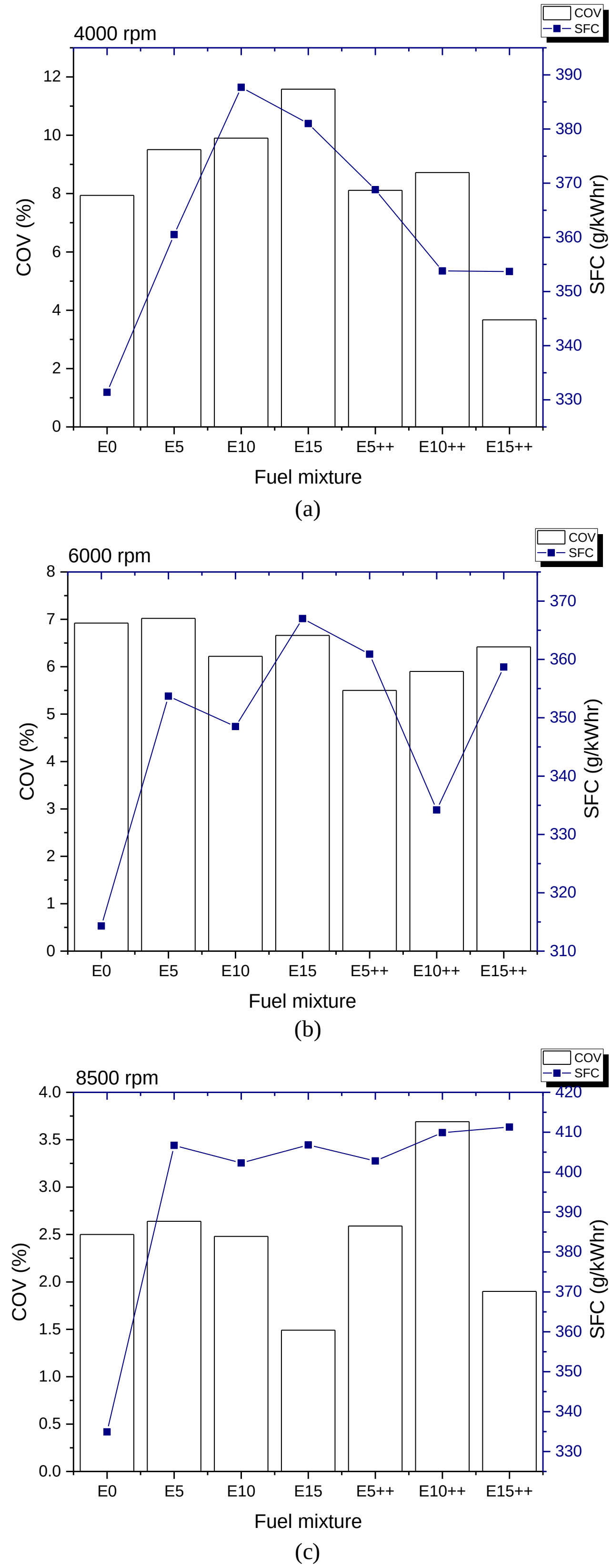


Figure 5. COV vs SFC; 4000 rpm (a), 6000 rpm (b) and 8500 rpm (c)

CONCLUSION

Based on the research that has been done the following conclusion can be made, gasoline-ethanol blend with oxygenated additives in gasoline decrease variation in combustion pressure occurrences, lower COV. The addition of oxygenated additive to gasoline-ethanol blend decreases SFC compared with their own respective mixture without additive. This is due to the oxygen content in the additive, so the combustion process improved which means more power. It can be seen that the correlations between COV and SFC are as COV value increase the SFC increases, and as COV value decreases the SFC decreases too. It shows that lower COV value indicate that the least variation in combustion pressure occurs so the combustion process improved and SFC decreased.

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