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Exhaust emissions analysis of gasoline motor fueled with corncob-based bioethanol and RON 90 fuel mixture

Widiyanti [a, *], Muhammad Alfian Mizar [a], Christian Asri Wicaksana [b], Didik Nurhadi [a], Kriya Mateeke Moses [c]

[a] *Department of Mechanical Engineering, State University of Malang*
Jl. Semarang no. 5, Malang, 65145, Indonesia,
[b] *Bachelor Program, Department of Mechanical Engineering, State University of Malang*
Jl. Semarang no. 5, Malang, 65145, Indonesia,
[c] *Graduate school of technological and vocational education, National Yunlin University of Science and Technology,*
123 University Road, Section 3, Douliou, Yunlin, 64002, Taiwan

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Abstract

One of the viable solutions to the fossil fuel energy crisis was to seek alternative sources of environmentally friendly energy with the same or better quality such as bioethanol. It was possible to produce bioethanol from organic waste, e.g., corncob. This research aimed to obtain the lowest exhaust emission levels of CO and CO_2 generated from a gasoline motor that used a mixture of bioethanol containing 96 % corncob and RON 90 fuel. This research was experimental using Anova statistical data analysis method. The results showed that the lowest average of CO emissions was 0.177 vol% using E_{100} fuel, and the highest average was 2.649 vol% using 100 % RON 90 fuel, displaying a significant difference. The lowest average of CO_2 emissions was 6.6 vol% using E_{100} fuel, and the highest was 7.51 vol% using 100 % RON 90 fuel, which was insignificantly different. The mixture variation with the lowest CO and CO_2 emissions was E_{100}.

Keywords: RON 90 fuel; corncob-based bioethanol; gasoline generator; CO and CO_2 exhaust emissions.

I. Introduction

Waste is a result of various operations of production and consumption to satisfy human needs. Physically, there are three types of waste: gas, solid, and liquid. Organic waste is the most produced waste globally, particularly in East Asia and the Pacific, reaching up to 62 % [1][2]. An example of organic solid waste without optimal handling is corncob. Corncob is the core of the female floral organ to which the kernels are attached. Corncobs have low utility and economic value because they are most beneficial as animal feed or a substitute for firewood. Increasing the utilization of corncob waste and its financial cost can be gained through bioconversion method, a method to turn waste into fuel such as bioethanol [3][4]. During 1969 to 2015, the year 2015 produced the highest maize production in Indonesia of 20,667 million tons [5].

Bioethanol is a biofuel that is renewable as long as there are sunlight, water, oxygen, and agriculture practices [6][7]. Bioethanol is superior to other fuel oils in the market because it has a higher oxygen content to burn perfectly, higher octane number, and is more environmentally friendly because it contains lower CO content [8][9]. Based on the above data, bioethanol is an alternative energy that becomes the most recommended renewable energy and could solve the existing pollution problems [10]. The most common ingredients in bioethanol are molasses [11] and crude fiber materials that high in carbohydrate, lipid, and nutrient contents [12][13][14]. Ethanol can be used in its pure form, mixed with gasoline, or interacted with hydrogen to create fuel cell energy source for internal combustion [15][16]. Potential plants for bioethanol production are those with high carbohydrate content, such as sugarcane, sugarcane juice, sugar palm, sorghum, cassava, cashew (cashew waste), arrowroot, banana stem, sweet potato, corn,

* Corresponding Author. Tel: +62-8123118193
E-mail address: widiyanti.ft@um.ac.id

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Table 1.
Comparison results of CO and CO_2 exhaust emission from a mixture of RON 90 and Bioethanol

No.	Load	100 % RON 90		75 % RON 90+E_{25}		50 % RON 90+E_{50}		25 % RON 90+E_{75}		E_{100}	
		CO (vol%)	CO_2 (vol%)	CO (vol%)	CO_2 (vol%)	CO (vol%)	CO_2 (vol%)	CO (vol%)	CO_2 (vol%)	CO (vol%)	CO_2 (vol%)
1.	200 W	1.79	6.38	0.94	5.91	0.14	6.53	0.01	5.94	0.13	4.94
2.	400 W	2.37	7.13	1.10	6.14	0.21	6.92	0.10	6.46	0.15	5.79
3.	600 W	2.43	7.60	1.28	7.27	0.25	7.10	0.11	6.75	0.16	6.52
4.	800 W	2.82	7.70	1.58	8.08	0.26	7.25	0.14	7.94	0.18	7.04
5.	1000 W	3.12	7.95	1.67	8.52	0.32	8.15	0.34	8.28	0.21	7.43
6.	1200 W	3.37	8.31	1.85	9.00	0.45	8.34	0.48	8.71	0.23	7.88

corncob, straw, and bagasse (sugarcane bagasse) [17]. Ethanol is a liquid with a distinct odor [18], flammable, colorless [19], water-soluble [20], and volatile [21].

Until 2015, the global primary energy consumption consists of 7 % water power, 4 % nuclear, 33 % oil, 30 % coal and 24 % natural gas [22][23]. The world energy consumption is projected to rise by 47.41 % from 2010 to 2040 [23] with the non-OECD countries, for example, Indonesia, dominate the consumption [22]. The newest type of fuel in Indonesia is RON 90 or commonly called Pertalite with 90 octane number. Pertalite is created by adding an additive element in its production in the refinery. Pertalite consists of naphtha–a refinery material with a boiling point between gasoline and kerosene and RON of 65 to 70, a high octane mogas component (HOMC) which has a RON of 92 to 95, and a fuel additive called Eco Save [24].

The previous research discussed the measurement of CO, CO_2, HC, and N_2 exhaust emissions on lightweight transportations [25][26][27][28]. Park [29] also examined the premixing effect of HC, CO, and NOx exhaust emissions from a mixture of bioethanol and gasoline. The emission test and machine performance fueled with a mix of biodiesel and ethanol had an inversely proportionate result between CO and CO_2 [30], meanwhile, adding more than 20 % ethanol in biodiesel did not affect the machine performance [31].

This research aimed to determine the exhaust emission levels of CO and CO_2 generated from a gasoline motor fueled with a mixture of bioethanol containing 96 % corncob and RON 90 fuel and to identify which variation of fuel mixture has the lowest exhaust emission level of CO and CO_2. The update in this study was the optimal composition of the corncob bioethanol fuel and RON 90 mixture with minimal corrosive levels.

II. Materials and Methods

This study used an experimental research method which is aiming to examine the effect of a given treatment under controllable conditions. The analysis in this study used the descriptive statistic and One Way Anova statistical test [32]. The descriptive analysis was useful to analyze the overall observation of CO and CO_2 exhaust emission level while the One Way ANOVA statistical test was used to test the hypothesis.

Several instruments in this research were helpful to facilitate data collection from sample tests so that the generated data were more accurate, comprehensive, complete, and systematic and established easy-processing research. The tests used a gasoline generator fueled with a mixture of corncob-based bioethanol and RON 90 fuel as the device. The engine performance analyzation aimed to obtain the CO and CO_2 emissions at a constant engine speed of 3000 Rpm. This research used a digital mass scale, measuring cups, Erlenmeyer flasks, volumetric flasks, volumetric pipettes, stopwatch, ammeter, light bulbs, tachometer, and digital Stargas 898 as the measuring instruments. The materials in this research were corncob-based bioethanol with 96 % purity level and RON 90 fuel. This research conducted the tests according to the five fuel mixtures with different concentrations of corncob-based bioethanol and RON 90 fuel in a gasoline generator. The five variations of the fuel mixture were 100 % RON 90, 75 % RON 90 + E_{25}, 50 % RON 90 + E_{50}, 25 % RON 90 + E_{75}, and E_{100}.

III. Results and Discussions

This experimental research answered the question on the best mixture ratio of fuels to create the lowest CO and CO_2 emission. The tests mixed both fuels in five ratio variations to obtain it. The results at Table 1 shows that from five mixture variations of RON 90 and corncob-based bioethanol, there were uniformed results; in which more load generated more CO and CO_2 exhaust emissions. The results were different from the experiment of Ehsaan [33], that declared that CO_2 exhaust emission was insignificantly increased, unlike the CO exhaust emission.

The data shown in Figure 1 addresses that the use of fuel mixture containing RON 90 fuel and corncob-based bioethanol produced a lower CO exhaust emission compared to the 100 % RON 90 fuel. This result occurred because ethanol has more oxygen content than RON 90 fuel, so the fuel combustion process was more likely to be perfect and generated fewer exhaust emissions [34]. Ethanol has an oxygenate compound with one OH in its molecular structure [35]. The presence of inherent oxygen in inert ethanol helps the combustion process [36] in the cylinder because it improved the atomization of air and fuel mixture. The use of 100 % RON 90 fuel produced the highest CO emissions of 3.373 vol% under a load of 1200 W and the 25 % RON 90 + E_{75} fuel generated the lowest CO emission level of 0.01 vol%

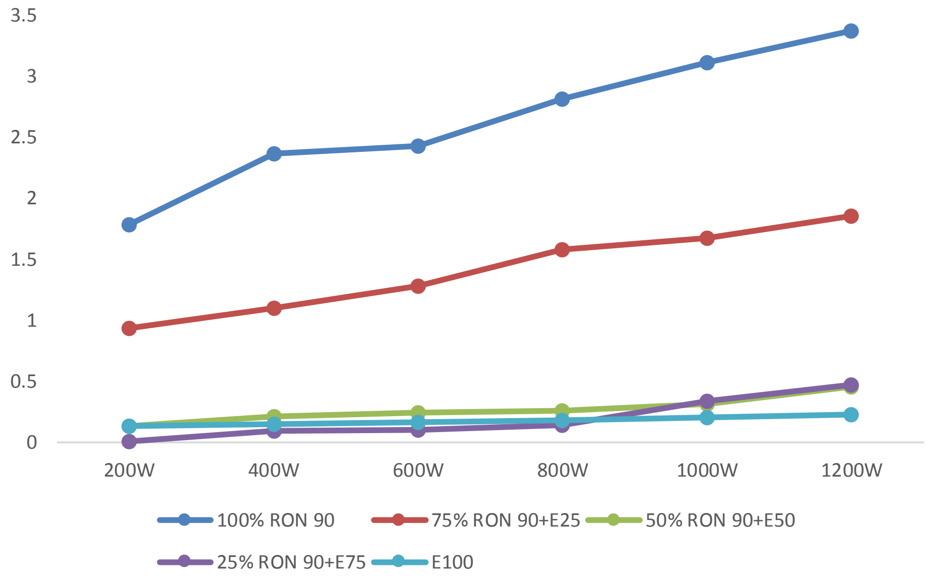

Figure 1. Comparison results of CO exhaust emission (in vol%)

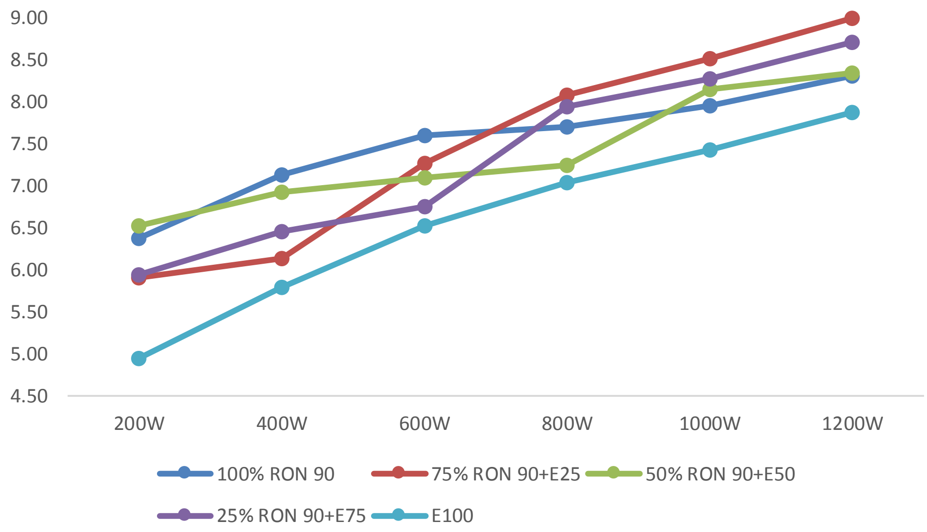

Figure 2. Comparison results of CO_2 exhaust emission (in vol%)

under a load of 200 W. Using the 100 % RON 90 fuel of 2.649 vol% generated the highest average of CO emissions and the E_{100} fuel produced the lowest one of 0.177 vol%.

Similarly, the CO_2 emission comparison result shown in Figure 2 also showed that the addition of corncob-based bioethanol to RON 90 fuel had produced lower CO_2 emissions than the use of 100 % RON 90 fuel. Overall, the CO emission levels were lower than the CO_2 emissions. The engine with 75 % RON 90 + E_{25} fuel mixture under a load of 1200 W produced the highest CO_2 emission level of 9 vol% and the engine using the E_{100} fuel under a weight of 200 W generated the lowest one of 4.9 vol%. On average, the engine with the 100 % RON 90 fuel made the highest CO_2 emission of 7.51 vol%, and that fueled with the E_{100} fuel produced the lowest average of 6.6 vol%.

IV. Conclusion

This research investigated the exhaust emission in gasoline motor fueled with a mixture of RON 90 gasoline fuel and corncob-based bioethanol. The results indicated that the CO_2 emission level tended to increase as with the increasing loading. Overall, CO emissions were lower than CO_2 emissions. The more the ethanol content in the fuel mixture, the lower the CO emissions. On the other hand, the CO_2 exhaust emission had significantly different results. Generally, the test results of CO_2 exhaust emission were similar to the CO exhaust emission; in which they increased with the increasing load and decreased along with the additional ethanol content in the mixture. Based on those results, the CO exhaust emissions were significantly different, while CO_2 emissions were insignificantly different. The recommended fuel to be used was E_{100} because it had the lowest CO and CO_2 exhaust emissions compared to other mixtures. However, due to the corrosive properties of ethanol, there needed modification in the fuel tank and its channel. Furthermore, it was possible to mix the bioethanol with fuel mixtures from the market to decrease the corrosive that might occur with the recommended combination was 25 % RON 90 + E_{75}. Based on the results, the best fuel mixture was 25 % RON 90 + E_{75}. This composition had the lowest CO and CO_2 exhaust emissions and lowest corrosive property compared to the pure E_{100} composition.

Declarations

Author contribution

Widiyanti and C.A. Wicaksana contributed equally as the main contributor of this paper. All authors read and approved the final paper.

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Conflict of interest

The authors declare no conflict of interest.

Additional information

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