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The Optimization Performance of Mixed Fuel Gasoline RON 88, 92, 98 with Bioethanol on Spark Ignition Engine

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***Abstract*—The pollution produced by combustion products from motor vehicle engines raises environmental problems that must be resolved. One way is to replace gasoline with biofuels such as bioethanol. The use of bioethanol as fuel is usually done by mixing bioethanol at a certain level with gasoline. The result of this mixing causes an increase in the octane number of the fuel. With the increase in the octane number, it is necessary to modify the parameters of the combustion process to make it more optimal. Generally, gasoline sold in Indonesia has octane values of RON 88, 92, and 98. The aim of this research is to optimize the performance of the mixed fuel bioethanol and gasoline RON 88, 92, and 98 by changing the injection duration and ignition timing of spark-ignition engine. The results of the research show that the torque and engine power have the highest values when gasoline is mixed with 30% bioethanol and the ignition timing is made 2o CA more advanced with the condition for injection duration at the standard-setting.**

Keywords : Bioethanol, Optimization, Research Octane Number, Ignition Timing, Injection Duration.

I. INTRODUCTION

As time goes by, environmental problems are increasing. One of the most common environmental problems is the problem of pollution from combustion products such as burning coal for power plants or from combustion of motorized vehicles. The motorized vehicles produce emission that contain CO_2, HC, CO and NO_x [1-3.] Based on the census of the Indonesian statistics center, the number of motorbikes used in Indonesia reached 120 million vehicles in 2018 [4].

Motor vehicles generally use 2 types of engines, namely diesel engines and spark ignition engines. Spark ignition engines generally use gasoline as fuel in order to do work. The use of gasoline is still a problem because the combustion products are considered to pollute the environment [5]. Therefore, alternative fuels that are more environmentally friendly are needed to replace gasoline such as bioethanol.

Bioethanol is a renewable energy source that can be an alternative to solve the problem of pollution produced by combustion emissions from the internal combustion engine because bioethanol comes from fermentation of vegetable raw materials [6]. The use of bioethanol as fuel in the SI Engine is generally done by mixing bioethanol at a certain level with gasoline [7]. Mixing bioethanol with gasoline can increase the octane value of the fuel. The Research Octane Number (RON) is a parameter that shows the ability of the fuel not to burn at high temperatures and pressures [8]. As research conducted by Bambang et al on the effect of a mixture of gasoline and bioethanol on the octane value of fuel, it shows that the higher the level of bioethanol is added, the octane value of gasoline also increases [9]. The addition of bioethanol content in gasoline can increase power and torque and reduce CO and HC emissions [10-13]. In general, the RON value of gasoline sold in Indonesia ranges from 88 to 98 [14].

Increasing the octane value of the fuel can affect the performance of the engine, especially engines sold in the market. This is because the specifications of the engine have been determined according to the RON of fuel that is generally sold in the Indonesian market. Therefore, modifications are needed so that the engine can work more optimally. Modifications can be made by changing some of the engine operating parameters such as Ignition Timing and Injection duration. Ignition timing is an important parameter in a spark ignition engine [15, 16]. Using a suitable ignition timing can increase the maximum pressure and temperature of the combustion [17]. In addition, changes in injection duration also greatly affect engine performance because it aims to get the right Air Fuel Ratio so that combustion becomes better [18].

The purpose of this research is to optimize the performance of the fuel in order to get better power and torque after adding bioethanol content.

II. MATERIAL AND METHOD

Tests were carried out using a 150 cc Spark Ignition Engine with specifications as shown in table 1. AVL Eddy Current Dynamometer is used to obtain power and torque data from the engine. Engine and AVL Eddy Current Dynamometer specification is shown in Table I and II.

TABLE I. ENGINE SPECIFICATION

Engine Type	4 Stroke, SI Engine, DOHC, Air Cooled
Cylinder	1 (Single)
Bore x Stroke	57.3 mm x 57.8 mm
Volume	149.4 cc
Compression Ratio	11.3 : 1
Fuel Supply System	Injection (PGM-FI)
Spark Ignition	NGK MR9C-9N/ND U27EPR-N9

TABLE II. AVL DYNAMOMETER SPESIFICATION

Model	**Max Power (kW)**	**Max Speed (RPM)**	**Max Torque (Nm)**	**Moment of Inertia (kg m^2)**
AVL Eddy Current Dynamometer DP 40	40	17000	75	0.0225

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This study uses gasoline with RON which is commonly sold in the Indonesian market, namely RON 88, 92, and 98. Each type of fuel is mixed with bioethanol content of 0-30%.

The modification made is by adding an ignition timing of 2° CA and adding an Injection Duration of 10% using the Engine Control Module (ECM). Data is taken at shaft speed of 1000, 1500, 2000, 2500 rpm with 100% load conditions or Wide Open Throttle.

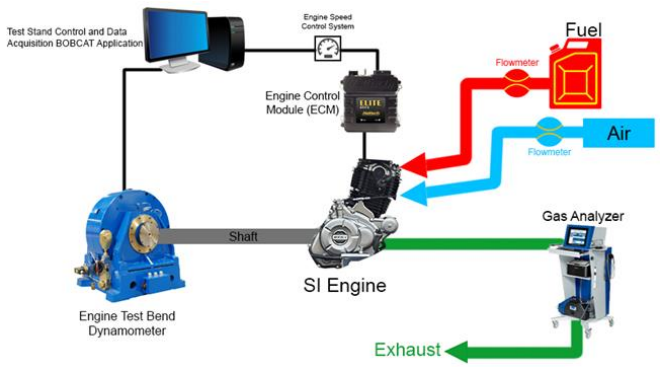

Fig. 1. Experimental Setup

Experimental setup of this research is shown in Fig.1. This research was conducted at the Research and Development Center for Oil and Gas Technology "LEMIGAS", Jakarta.

III. RESULT AND DISCUSSION

A. *Analysis of Research Octane Number*

Testing of fuel specifications is carried out using the F1 Cooperative Fuel Research (CFR) engine with reference to the ASTM D 2699 standard [19].

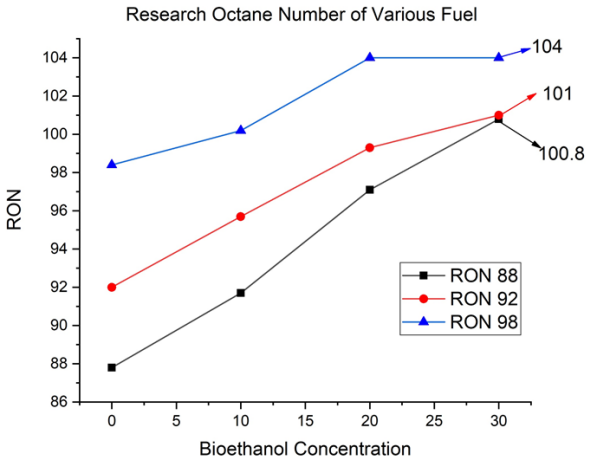

Fig. 2. Research Octane Number Value with additional Bioethanol

As shown in Fig. 2, the RON value of each fuel variation increases with increasing levels of bioethanol in the mixture. For RON 88, there was an increase in RON by 14.5%, RON 92 by 9.7%, RON 98 by 6.1% in a mixture of 30% bioethanol content.

B. *Torque*

The test results show that the maximum torque value of each variation of the fuel mixture is at a speed of 2000 rpm. Comparison of torque values on variations in fuel and operating parameters is shown in the figure 3, 4, and 5.

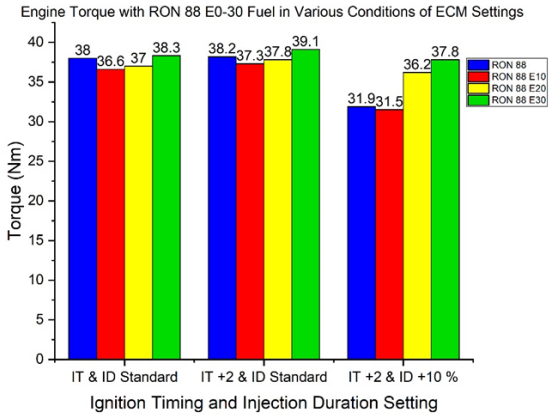

Fig. 3. Torque of RON 88 E0-30 Fuel in Various ECM Settings

From Fig. 3 it can be seen that the highest torque is in the combustion of RON 88 fuel with 30% bioethanol when the Ignition Timing is changed and the Injection Duration is in standard conditions. The highest torque value is 39.1 Nm which shows an increase of 2.7% compared to pure gasoline RON 88 in standard settings. After adding the injection duration, the torque value has decreased. This is because the combustion of the mixture of fuel and air is not stoichiometric because the fuel increases more, causing poor combustion. [20, 21].

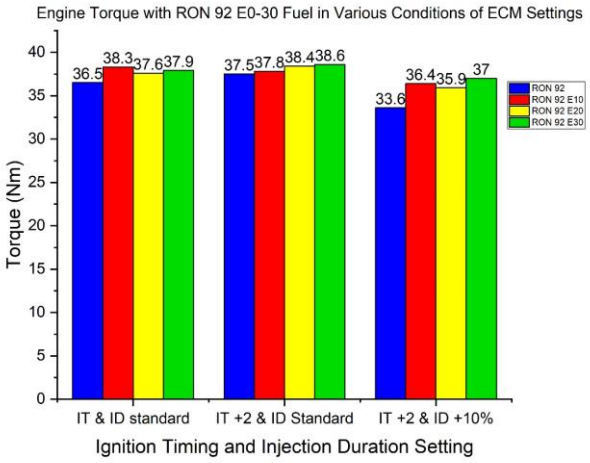

Fig. 4. Torque of RON 92 E0-30 Fuel in Various ECM Settings

Just like RON 88, RON 92 fuel torque has the highest value in a mixture of 30% bioethanol and an additional ignition time of 2o CA is added, which is 38.6 Nm as shown in Fig. 4. The torque value increased by 5.7% when compared to the fuel torque of RON 92 under standard conditions and without the addition of bioethanol content. The decrease in torque value also occurs when adding 10% to the Injection Duration due to the less stoichiometric mixture.

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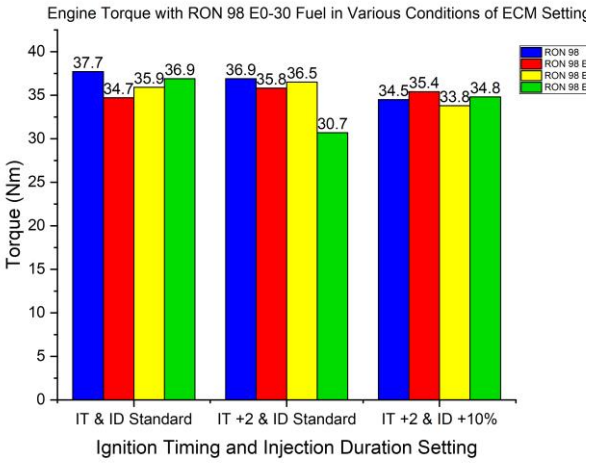

Fig. 5. Torque of RON 98 E0-30 Fuel in Various ECM Settings

In contrast to RON 88 and RON 92, from Fig. 5 it can be seen that RON 98 has decreased torque value along with the increase in bioethanol content. The highest torque value is 37.7 Nm for fuel without bioethanol mixture and on standard parameter conditions. This is because the higher the RON value, the more difficult the fuel to burn and it is not in accordance with the Compression Ratio of the engine used.

C. Power

The test results show that the maximum power value of each variation of the fuel mixture is at a speed of 2500 rpm. Comparison of power values for variations in fuel and operating parameters is shown in Fig. 6, 7 and 8.

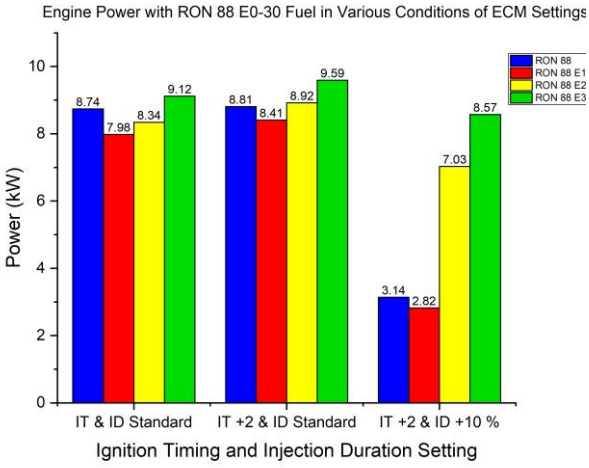

Fig.6. Power of RON 88 E0-30 Fuel in Various ECM Settings

As shown in Fig. 6, the highest power value is 9.59 kW in the fuel mixture of RON 88 and Bioethanol 30% and after adding 2º CA ignition timing with standard injection duration. Power has increased by 9.7% compared to the power of RON 88 fuel without bioethanol mixture and standard settings. Power has decreased drastically when added 10% injection duration. This shows that there is poor combustion when the fuel level increases.

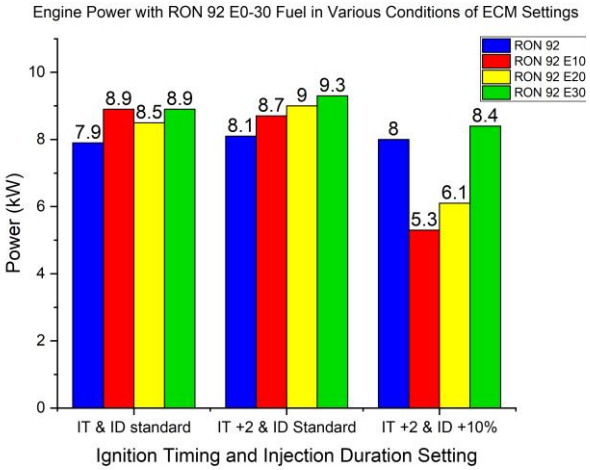

Fig. 7. Power of RON 92 E0-30 Fuel in Various ECM Settings

Similar to RON 88, the highest power produced by RON 92 is 9.3 kW with an additional 30% bioethanol content at ignition timing plus 2º CA. The power increased by 17.7% from the fuel in standard conditions without bioethanol mixture. From Fig. 7 it can also be seen that there is a decrease in power when the injection duration is increased by 10%.

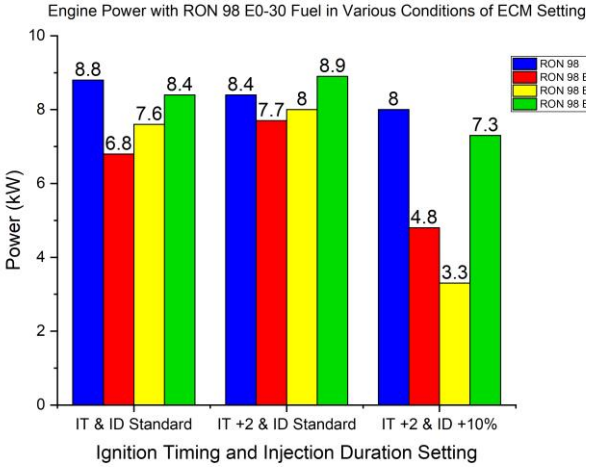

Fig. 8. Power of RON 98 E0-30 Fuel in Various ECM Settings

The highest power produced by RON 98 is 8.9 kW, this power produced does not experience a significant increase when compared to fuel in standard conditions without bioethanol mixture. As shown in Fig. 8, the increase was only 1.1%. This is because the higher the octane value, so it is not in accordance with the engine compression ratio specification which causes poor combustion.

IV. CONCLUSION

The results showed that the higher levels of bioethanol mixed into gasoline fuel could cause an increase in the research octane number of the fuel. Gasoline RON 88 experienced an increase in octane value by 14.5%, RON 92 by 9.7%, RON 98 by 6.1% at a mixture of 30% bioethanol content. To get better

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power and torque, modifications can be made by changing the ignition timing by 2º CA but not changing the injection duration. The torque of RON 88 and 92 fuels increased by 2.8% and 5.7% along with the increase in Bioethanol and Ignition Timing levels but in contrast to RON 98 which did not experience significant changes due to having too high an octane value. The addition of an injection duration of 10% causes a decrease in power and torque due to the combustion conditions which are too rich in fuel.

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REFERENCES

[1] Hochgreb, Simon, Combustion Related Emissions in SI Engines. Handbook of Air Pollution From Internal Combustion Engines. Academic Press. 1998. p.118-170.

[2] Milton, Brian E, Control Technologies in Spark-Ignition Engines. Handbook of Air Pollution From Internal Combustion Engines. Academic Press. 1998. p.189-258.

[3] Zvirin, Yoram., Marcel Gutman., Leonid Tartakovsky, Fuel Effects on Emissions. Handbook of Air Pollution From Internal Combustion Engines. Academic Press. 1998. p.547-651.

[4] Number of Motorized Vehicles by Type. 2020, Central Bureau of Statistics Republic of Indonesia.

[5] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.

[6] Mohapatra, Sonali., Ramesh C.Ray., S. Ramachandran, Bioethanol From Biorenewable Feedstocks: Technology, Economics, and Challenges. Bioethanol Production from Food Crops, 2019. p. 3-27.

[7] Wibowo, C.S., et al., The Effect of Gasoline-Bioethanol Blends to The Value of Fuel's Octane Number. E3S Web Conf., 2018. 67.

[8] Rashid, A.K., et al., Combustion Characteristics of Various Octane Rating Fuels for Automotive Thermal Engines Efficiency Requirements. Energy Procedia, 2019. 157: p. 763-772.

[9] Sugiarto, B., et al., Characteristic of Gasoline Fuels in Indonesia Blend with Varying Percentages of Bioethanol. E3S Web Conf., 2018. 67.

[10] Adian, F., et al., The effect of 5% ethanol in 88, 92, and 98 RON gasoline on motorcycle engine performance. AIP Conference Proceedings, 2019. 2114(1): p. 020018.

[11] Yüksel, F. and B. Yüksel, The use of ethanol–gasoline blend as a fuel in an SI engine. Renewable Energy, 2004. 29(7): p. 1181-1191.

[12] Wibowo, C.S., et al., The effect of bioethanol-varying gasoline blends on performance and emission of SI engine 150 CC. AIP Conference Proceedings, 2019. 2062(1): p. 020020.

[13] Adian, F., et al., Comparison of the effect of 10% ethanol addition in 88 and 98 gasoline RON on motorcycle engine performance. AIP Conference Proceedings, 2020. 2230(1): p. 050003.

[14] Sugiarto, B., et al., Comparison of the gasoline fuels with octane number variations 88, 92 and 98 on the performance of 4 strokes single cylinder 150 CC spark-ignition engine. AIP Conference Proceedings, 2019. 2062(1): p. 020018.

[15] Papagiannakis, R., D. Rakopoulos, and C. Rakopoulos, Theoretical Study of the Effects of Spark Timing on the Performance and Emissions of a Light-Duty Spark Ignited Engine Running under Either Gasoline or Ethanol or Butanol Fuel Operating Modes. Energies, 2017. 10: p. 1198.

[16] Annand, W.J.D., *Chapter Two - Gasoline Engines*, in *Internal Combustion Engines*, C. Arcoumanis, Editor. 1988, Academic Press. p. 31-99.

[17] Qian, Y., et al., Engine performance and octane on demand studies of a dual fuel spark ignition engine with ethanol/gasoline surrogates as fuel. Energy Conversion and Management, 2019. 183: p. 296-306.

[18] Pulkrabek, W.W., Engineering Fundamentals of the Internal Combustion Engine, 2nd Ed. Journal of Engineering for Gas Turbines and Power, 2004. 126(1): p. 198-198.

[19] ASTM, D2699-19 Standard Test Method for Research Octane Number of Spark-Ignition Engine Fuel. 2019, ASTM International.

[20] Stone, R., *Introduction To Internal Combustion Engine* 4th Edition ed. 2012: SAE International and Macmillan Press.

[21] Chung K, Law, Combustion Physics. Cambridge University Press. 2006.