Effect of Ethanol-96% in Gasolinewith Mixture Ratio of 1:9 And 2:8 On The Combustion And Emission Of 125cc Four-Stroke Engine

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ABSTRACT–*This paper is purposed to describe the development of a main control unit (MCU) in an engine to support the transition in the use of fuel, from gasoline to ethanol. The study was conducted in several stages, beginning with the initial determination of the engine character engine, followed by an in-depth observation on the effect of ethanol in a gasoline mixture with proportion of 1:9 and 2:8. Furthermore an MCU was designed to optimize the combustion process of the mixture. So far, it is found that the addition of ethanol results in less perfect combustion in a standard engine while at same time decreasing the CO gas emission level, increasing HC and O2 gases, whereas the CO2 gas tends to remain.*

Keywords – *MCU, ethanol, combustion, four stroke engine.*

I. INTRODUCTION

The increasing number of vehicles influences directly the increase in fuel consumption. This condition is continuing unting one day there is no more oil reserves available. It is predicted that oil reserves would run out in about 30 years.

On the other side, the increasing number of fuel consumption has negative impacts on the environment, as it declines the air quality because of the pollution. This condition impact public healthadversely, especially in large cities.

To anticipate the aggravating condition, many researchers keep trying to look for alternative energy sourceswhich is renewable, for example those derived from plants, to substitute fuel. One of the renewable energy source is ethanol.

Many reseaches have been done on the use of ethanol as a substitute for fuel (Gasohol: a mixture of gasoline and ethanol). The content of ethanol used varies from some concentration value up to pure ethanol (100 %), for example E15 (15% of ethanol ethanol mixed with 85% of gasoline)[1], E20[2], and E100[3]. The use of E20 to subsitute for gasoline in a vehicle without any modification of the engine resulted in the relatively same performance with a significant reduction in toxic emissions[2].

The study the results of which are presented in this paper was conducted to design and develop a simple electronic device (MCU) to control the fuel ignition system in a vehicle, when ethanol in a certain concentration is used as subsitute for fuel. It is expected to contribute to the smooth transition from the dependence on oil fuel to the use of ethanol as renewable fuel derived from plants. The need for such this MCUis related to the change in fuel characteristics which requires some changes in the fuel ignition system to result in an optimum combustion condition without having to make extreme modifications on the engine. Therefore, there will be no much problem and difficulty for vehicle users, so that the transition of the fuel types use would be readily accepted by the public.

This paper presented some of the results, namely the determination of the initial conditions when the engine uses gasoline (premium), E10, and E20. It is important to present these results as the data collection process was done using a 125cc small-capacity engine commonly used by people, and using a mixture of 96% ethanol containing certain amount of water, which will more or less affect the combustion process in the engine .

II. THE USE OF ETHANOL AS FUEL

Ethanol (ethyl-alcohol) is one type of alcohol that can be used as fuel. The use of pure alcohol in a 4-stroke engines mixed with gasoline in varying ratios can be used as fuel for engine with certain modifications. Ethanol which is already widely used is the type of E10 (Gasohol). This type of ethanol can be used by new vehicle 4-stroke engine which typically use gasoline without any modification. There are still no sufficient data about the implementation of E10 on old vehicles [4]. Comparison properties E10 and E20 is shown in Table I.

The use of E10 can produce optimum performance if the ignition is -1 degree in advance of the standard value, whereas the E20 needs -6 degrees[5].

TABLE I
Characteristics of gasoline, ethanol E10, and E20

Properties	Gasoline	Ethanol	E10	E20
Heating value (kJ/kg)	44,000	27,000	41,900	40,000
Stoichiometric air/fuel ratio	14.6	9	14	13.5

Some countries have already developed cars with ability to adapt to the changes in fuel. In Brazil the Hi-Flex technology was developed and embedded in n a Renault Clio engine, making it able to use pure gasoline, gasoline-ethanol mix, or pure ethanol, as fuel. This ability is obtained by applying the automatic settings to obtain optimum engine efficiency.

The Clio's power curve measurement results showed an increase of 1 horsepower throughout the revolution speed range of the engine when using ethanol with 5-8 degrees of ignition in advance of the optimal setting when using gasoline.

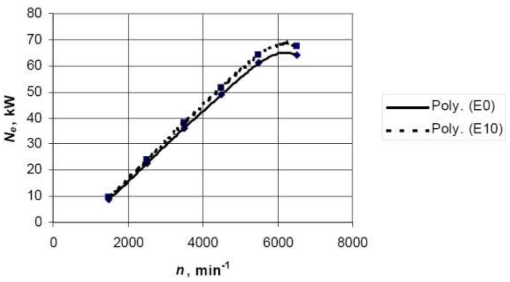

Fig. 1. Effect of ethanol blends on power [7]

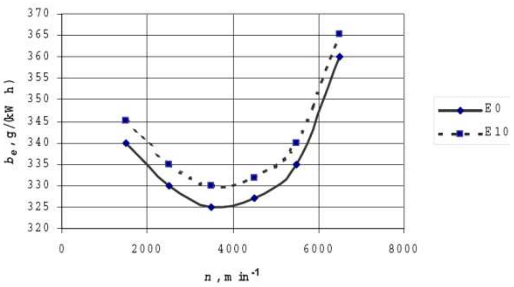

Fig.2. Effect of ethanol blends on specific fuel consumption[7]

Being compared to gasoline, ethanol has a disadvantage of Lower Heating Value (LHV), approximately 26.8 MJ/kg lower than gasoline (43.2 MJ/kg),making the engine less powerful. Another disadvantages is that its heating calorific value during vaporization is much higher (841 kJ/kg) than gasoline (360 kJ/kg), making it difficult to burn. Yet ethanol has the advantage that the amount of air required to achieve the stoichiometric condition is 9.0078 smaller than gasoline (14.6). The other benefit is that the ethanol posseses the higher value of Research Octane Number(RON) than gasoline. Its RON value is 129, which is much higher than that of gasoline(95) , soit can be functioning with a higher compression ratio to produce greater efficiency. AS a consequence, to improve the engine performance it is required to supply the engine with denser and more compression, which can be practically done by applying a turbocharger [2].

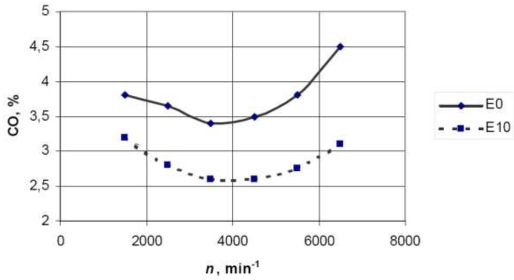

Fig.3. Effect of ethanol blends on CO emission[7]

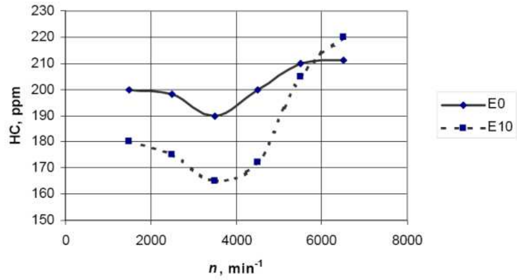

Fig.4. Effect of ethanol blends on HC emission[7]

The flame speed of ethanol is higher than that of gasoline. Ethanol has a laminar flame speed of 41-50 cm/s, whereas gasoline has a laminar speed of 33-39 cm/s, under the room condition. Flame speed increases with the compression increase in combustion chamber which reaches values greater than 10 bar and a temperature of 700 K[6]. Consequently, a proper ignition timing is required to gain optimum performance.

From some previous studies it is known that engine modifications are not required for the use of gasoline mixture up to 10% ethanol (E10). However, being compared to gasoline some changes in performance parameters can be observed[7]:

1. Gasoline octane >95, E10>98.9
2. Rising E10 fuel consumption of 2-3%
3. Rising power engine up to 5%
4. Decreasing E10 CO emissions of 10-30%
5. Rising E10 CO2 emissions of 5-10%.

Some other effects that appeared later after the addition of ethanol into gasoline are as follows:

1. Octan number became higher (RON of ethanol was 10, that of gasoline was 95), thus resulting cleaner combustion
2. The engine power became decreasing (84400Btu/galon of ethanol, 125000Btu/ galon of gasoline)
3. Engine ignition under cold condition became harder
4. Several other problems appeared, being associated with the corrosive nature of ethanol.

III. EXPERIMENTAL SETUP

Steps done during the study are begun with the determination of engine and fuel initial characteristics, which are the initial conditions when engine uses gasoline, E10, and E20. The following step is making a simulation to determine the optimum time of fuel ignition. Furthermore, an MCU is designed based on the results of engine characteristics determination and the ignition time mapping from simulation results. Finally, the designed MCU is tested to optimize the combustion process when using the E10 and E20.

The experiment was carried out at the Laboratory of Combustion Engine of Mechanical Engineering Department at Brawijaya University.

Some materials/ ingredients and equipments used are as follows:

• Material: premium gasoline with 88 octane
• Ethanol 96 %

whereas, the tools used are :

• Engine 4 stroke engine , 125 cc
• Tape measure exhaust emissions, Stargas 898
• Measuring cup

The measuring process is performed using some following steps :

1. Preparation of equipment, materials and measuring instruments
2. Retrieval of data when using premium gasoline motors
3. Retrieval of data when using E10 fuel. At this step, the things you should do are:
   • Discharging fuel container
   • Mixing fuel
   • Fuel suction
   • Ignition for stationary stable condition

• Data collection at some levels of engine speed, i.e. 1500, 3000 , 6000 and 9000 rpm

4. Retrieval of data for E20 fuel, the same treatment with step 3.

The data collection process should be done by an expert, in this case the technician and assistant of laboratory, as can be seen in Fig. 5.

Fig.5. Data collection process during exhaust emission gas testing

IV. RESULTS AND DISCUSSION

During the experiment, the testing equipment used was a 4-stroke motocycle engine of 125cc. The engine specification is shown in Table II, whereas the characteristics of gasoline and ethanol used can be seen in Table III.

TABLE II
Engine specification

	Part	
Engine	Bore x Stroke	52,4 x 57,9 mm
	Volume	124,9 cm3
	Compression ratio	9,0 : 1
	Valve	2 flaps, SOHC
	Valve in open	2° before TMA
	close	25° after TMB
	Valve exh open	34° before TMB
	close	0° after TMA
	Cylinder configuration	One cylinder 80° off vertical
Carburetor	Type of carburator	Type Piston Valve
	Diameter of venturi	18 mm or equivalent
	Diameter of manifold	23 mm
	Length of outer manifold	122 mm
	Length of inner manifold	77 mm

TABLE III
Characteristics of Ethanol and Gasoline

Information	Unit	Ethanol	Gasoline
		$CH_{1.814}$	$CH_3O_{0.5}$
Heat	MJ/kg	26.9	44.133
Density of gass (1 bar, 25 ^oC)	kg/m3	1.214	1.227
Density of liquid (15,5^oC)	kg/liter	0.79	0.7678
Boiling poin	^oC	78	27
Self ignition	^oC	423	257
Stoichiometry		9	14.7
RON		108	90-100
MON		92	81-90

After doing some experiments on exhaust emission gas using pure gasoline, E10, and then E20, the results shown in Table IV, V, and VI were obtained.

TABLE IV
Gas emission test results using gasoline E0

	Emission E0			
Rpm	CO (%vol)	CO2 (%vol)	HC (ppm vol)	O2 (%vol)
1500	1.65	7.83	596	6.27
	1.391	8.09	419	6.36
3000	2,074	8.98	207	4.59
	2.194	8.83	319	4.98
6000	3.531	8.28	99	4.59
	3.608	7.99	138	4.48
9000	0.940	9.43	194	4.94
	0.852	9.87	300	4.33

If it is desired to draw the data results of exhaust gas testing at certain engine speed and ethanol concentration of ethanol, the characteristics are shown in Fig. 6-9 for CO, CO2, HC, and O2 concetration subsequently.

TABLE V
Gas emission test results using gasoline E10

	Emission E10			
Rpm	CO (%vol)	CO2 (%vol)	HC (ppm vol)	O2 (%vol)
1500	0.215	7.75	1693	9.5
	0.199	7.52	1055	9.48
3000	0.224	4.86	2122	13.97
6000	0.177	9.84	1060	6.02
9000	0.341	10.39	483	4.89

TABLE VI
Gas emission test results using gasoline E20

	Emission E20			
Rpm	CO (%vol)	CO2 (%vol)	HC (ppm vol)	O2 (%vol)
1500	0.762	7.97	714	7.88
3000	0.164	6.55	1536	11.12
6000	0.097	9.34	449	6.72
9000	2.038	8.75	471	5.72

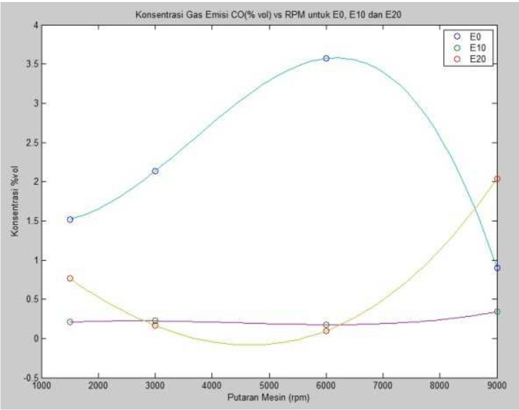

Fig. 6. Concentration of emission gas CO vs. rpm using E0, E10 and E20

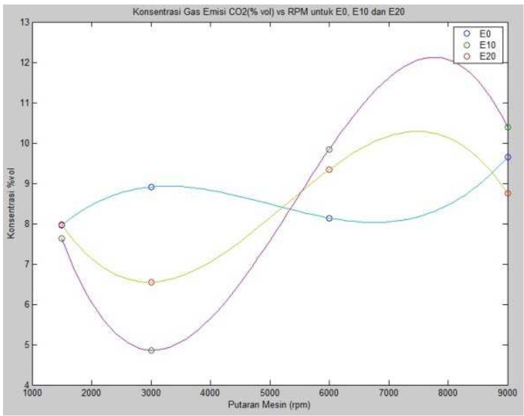

Fig. 7. Concentration of emission gas CO2 vs. rpm using E0, E10 and E20

The concentration of CO emissions are decreasing after using the E10 and E20. However, at high engine speed the use of E20 will result in the continuing increase of CO gas, even higher than on the use of gasoline. This fact is reflected from the difficulty found during the testing, whereit is hard to produce combustion using E20 containing ethanol-96%. The water content in the ethanol 96% could become the culprit of this difficulty. Combustion process becomes unstable and it was bursting several times. On the other hand, when E10 was used, the combustion process was normal. A setting one at the beginning is enough to produce good combustion condition at the other engine speed.

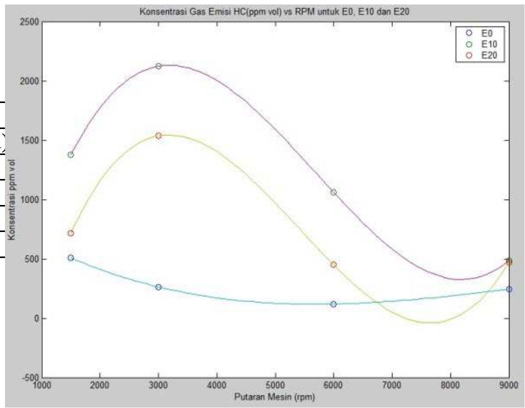

Fig. 8. Concentration of emission gas HC vs. rpm using E0, E10 and E20

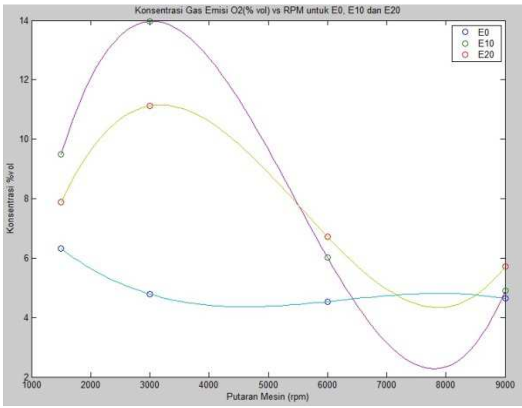

Fig. 9. Concentration of emission gasO2 vs. rpm using E0, E10 and E20

V. CONCLUSIONS

From the study conducted, some conclusions can be drawn as follows.

1. The mixture of ethanol of96% concentration and gasoline of 88-octane (premium) with proportion of gasoline:ethanol to be 90:10 (E10) results in a normal combustion requiring only once carburetor settings at the beginning, at an engine speed of 1500rpm. On the other hand, the use of E20 arrangements requires repeated setting to produce the desired combustion, otherwise it will be difficult to turn on the engine.
2. The process of mixing ethanol-96% with gasoline does not result in a good mixture, as separation layer between the two is still

visible being caused by the presence of water in the ethanol.

3. Design of MCU in the next research should enable to regulate the amount of flowing air to be mixed with the fuel.

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