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Impact of Methanol-Gasoline Fuel Blend on The Fuel Consumption and Exhaust Emission of A SI Engine

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Abstract. *In this study, the effect of methanol-gasoline fuel blend (M15, M30 and M50) on the fuel consumption and exhaust emission of a spark ignition engine (SI) were investigated. In the experiment, an engine four-cylinder, four stroke injection system (engine of Toyota Kijang Innova 1TR-FE) was used. Test were did to know the relation of fuel consumption and exhaust emission (CO, CO2, HC) were analyzed under the idle throttle operating condition and variable engine speed ranging from 1000 to 4000 rpm. The experimental result showed that the fuel consumption decrease with the use of methanol. It was also shown that the CO and HC emission were reduced with the increase methanol content while CO2 were increased.*

INTRODUCTION

Recently, air pollution and fuel crisis are two major issues that are worldwide concered. This happens because of the increasing development of science and technology, increasing population, increasing number of vehicles and a decline in fuel production. In the midst of increasingly depleted energy reserves, particularly of fuel oil, then obviously the situation is very worrying. Hence, this situation need for a way to reduce the high emissions from consumption of fuel oil by replacing fossil fuels with renewable fuel that is more environmentally friendly. One of the alternative energy biomass products that are less well known in this era and has the opportunity to become an alternative fuel is methanol.

Methanol can be produced from natural gas and coal gasification or biomass. Methanol has a high octane content than gasoline. This allows for a machine that uses methanol as a fuel has a higher compression ratio, and increase thermal efficiency. Compared with gasoline, methanol has several characteristics that is high octan content, lower boiling point, velocity rapid fire, high oxygen content (50% wt), can be atomized, it can be injected, can be mixed and simple chemical structure, so that all of these things help to reduce CO and hydrocarbon (HC emissions) [1]. Moreover, methanol have a smaller negative impact on the environment than gasoline and benzene [2]

Brinkman et al, measuring the octane content of the fuel blend of methanol-gasoline. They found that the octane content fuel increases with increasing amount of methanol in the fuel blend [3]. Zhao H, et al, researched on a car using a fuel blend of methanol-gasoline and showed results that the emissions of carbon monoxide (CO) and total hydrocarbons (THC) decreased respectively by 9% -21% and 1% -55% , while emissions of nitrogen oxides (NOx) increased by 175% -233% [4]. Celik, et al, researched on the effects of high compression ratio (CR) using pure methanol as a fuel in the singel cylinder engine. The results showed that a decline in emissions of CO, CO2 and NOx emissions with no loss of power when using methanol in CR 6/1. By increasing CR from 6/1 to 10/1 using methanol, the engine power and brake thermal efficiency (BTE) respectively increased by 14% and 36%. Moreover, emissions of CO, CO2 and NOx is reduced respectively by 37%, 30% and 22% [5]. Yanju et al, perform testing using three variations of fuel blend of methanol gasoline (M10, M20, M85) on SI engines. They claimed that with

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increasing fraction of methanol in gasoline, CO emissions can be decreased and M85 reduce CO emissions by 25%, and for methanol fuel blend ratio is low has no significant effect on the reduction of NOx emissions while M85 reducing Nox by 80% [6].

Dai, et al, conducted a study on passenger cars with Euro 4 standard using M15 fuel. The test results showed that THC and CO emissions from passenger cars fueled M15 decreased respectively 16% and7%, while NOx emissions increased by 85% compared to a gasoline engine [7]. This study uses a fuel blend of methanol-gasoline with varying composition (M15, M30 and M50). The aim of this study is to determine the effect blending ratio of methanol-gasoline to the fuel consumption and gas emissions produced. Experiments will be conducted with the engine speed differencethat is, 1000, 1300, 1600, 2000, 2300, 2600, 3000, 3300, 3600, 4000 and the engine idle rotation speed.

EXPERIMENTAL PROCEDURE AND EQUIPMENT

1. Engine and Equipment
   In this study, experiments conducted on 1TR-FE engine, 1998 cc, four-stroke, sixteen-valve, gasoline engine four stoke (SI) which is equipped with a system of variable valve timing (VVT) injection system with little modification is the addition of methanol controller that serves to change ECU command. Engine specifications can be seen in Table 1.

TABLE 1. Engine Specification of Toyota Kijang Innova

Engine	1TR-FE
Engine Type	4 one line cylindere, 16 valve, DOHC, VVT-i
cylinder (cc)	1,998
Diameter x stroke	86,0 x 86, 0
Maximum Power (ps/rpm)	136/5,600
Maximum Torque (kgm/rpm)	18,6/4000
fuel	Gasoline

The engine is linked to the scanner engine to see the parameters when the machine is working like a mass air flow (MAF), ignition timing, injection timing, air fuel ratio (AFR) and RPM engine where all the parameters that can indicate the fuel consumption. Exhaust emissions (HC, CO, and CO2) measured using a portable gas analyzer. Specifications gas analyzer can be seen in table 2.

TABLE 2. Specification of Gas Analyzer

Model No	SY-GA 401
Measuring Range	CO; 0.00-9.99% HC; 0-99999 ppm CO_2; 0.0-20.0% O_2; 0.0-25% λ; 0-2.000 AFR; 0.0-99.0
Operation Temp	0-40^{o}C
Power Source	AC 220V 60 Hz
Serial No	#956824
Merk	*SUKYOUNG MACHINE*

TABLE 3. Fuels Properties

Property	Methanol	Gasoline
RON	106	88
Stoichiometry air/fuel ratio	6.5	14.7
Density (kg/l)	0.79	0.74
Oxygen content by mass (%)	50	0
Volumetric energy content (MJ/l)	15.0	31.7
Heat of vaporization (kJ/kg)	1100	180-350
Specific CO2 emissions (g/MJ)	68.44	73.95
Lower heating value (MJ/kg)	20.09	42.9
Energy per unit mass of air (MJ/kg)	3.12	2.95
Reid vapour pressure (psi)	4.6	7
Adiabatic flame temperature (oC)	1870	2002
Initial boiling point	64	74
50	64	125
90	65	180
End boiling point	66	215

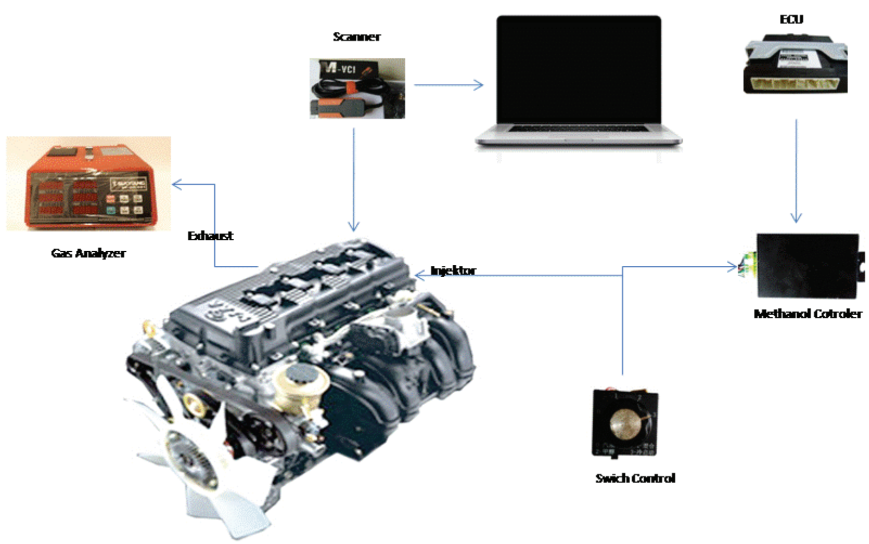

Figure 1. Experimental Setup

2. Fuels
   This research on this experiment using four fuel samples. Gasoline obtained from Pertamina gas stations. Methanol with a purity of 75% and received a certificate from the Central Technology of Prevention Industry Pollution (BBTPPI) Semarang. Gasoline blended with methanol to obtain the three mixtures (15%, 30% and 50%). Fuel blended is prepared before starting the experiment to ensure that fuel blend is homogeneous. Fuel properties are shown in Table 3.

3. Proccedure
Engine is started to warm the engine. Experimental performed on the engine speed at 1000, 1300, 1600, 2000, 2300, 2600, 3000, 3300, 3600, 4000 rpm and throttle position idle.

RESULT AND DISCUSSION

1. Fuel Consumption
The effects of fuel mixing methanol-gasoline on fuel consumption can be seen in Figure 2. The fuel consumption is relatively decreased with increasing percentage of methanol. Each of these reductions in fuel consumption for the M15, M30, and M50 are 9.5%, 7.2% and 3.1%. On the other hand the use of methanol to gasoline SI engines without any modifications will be relatively increases with the percentage of methanol in the mixture [8]. One of the causes of specific fuel consumption of the use of methanol fuel is higher than gasoline is due to *volumetric energy content* of methanol is lower than gasoline, thus causing more a mixture of methanol-gasoline needed to produce the same power compared to using gasoline. As we know that to obtain the optimum power and torque of the engine, the amount of air entering the cylinders in each cycle must be optimized. More air means more fuel burned and more energy is converted into power output.
Methanol as one type of alcohol, have air-fuel ratio (AFR) less than gasoline at 6.5: 1, while gasoline has AFR 14.7: 1. The small air-fuel ratio will result of high loss volumetric efficiency [9]. Methanol also has a heat of vaporization values are higher than the gasoline that is 1100 KJ / kg, while gasoline only 180-350 KJ / kg. Fuel with a high heat of vaporization will result in some loss in the volumetric efficiency [9].

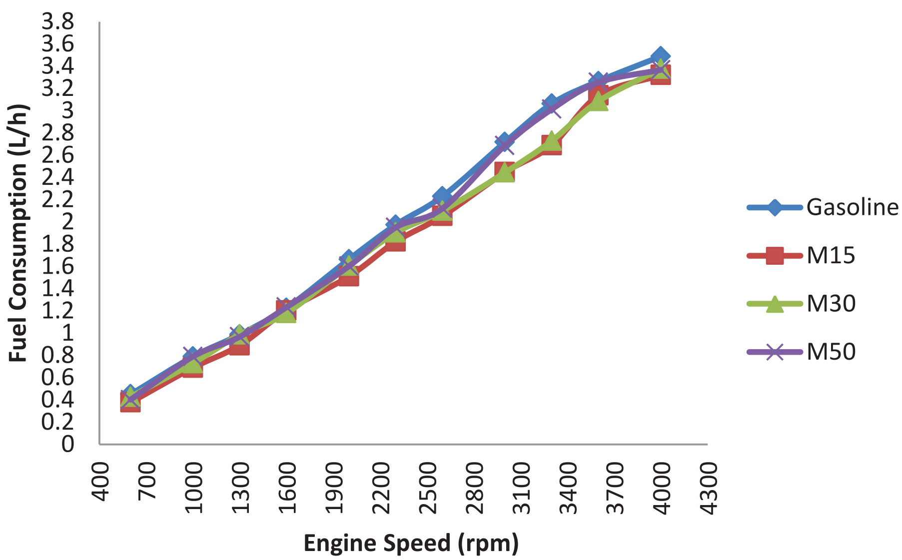

Figure 2. The effect of addition methanol on the fuel consumption

2. CO Emission
The effect of the methanol–gasoline blends on CO emission for different engine speeds is shown in Fig.3. The graph showed that when methanol percentage increases, the concentration of CO emission is decreases. This can explained by the oxygen content owing of methanol, in which an increase in of oxygen content of fuel will increase the further oxidation of CO during the engine exhaust process. Another significant reason of this reduction is that methanol (CH3OH) has less carbon than gasoline (C8H18). At the 3000 rpm exhaust showed lower CO emissions.

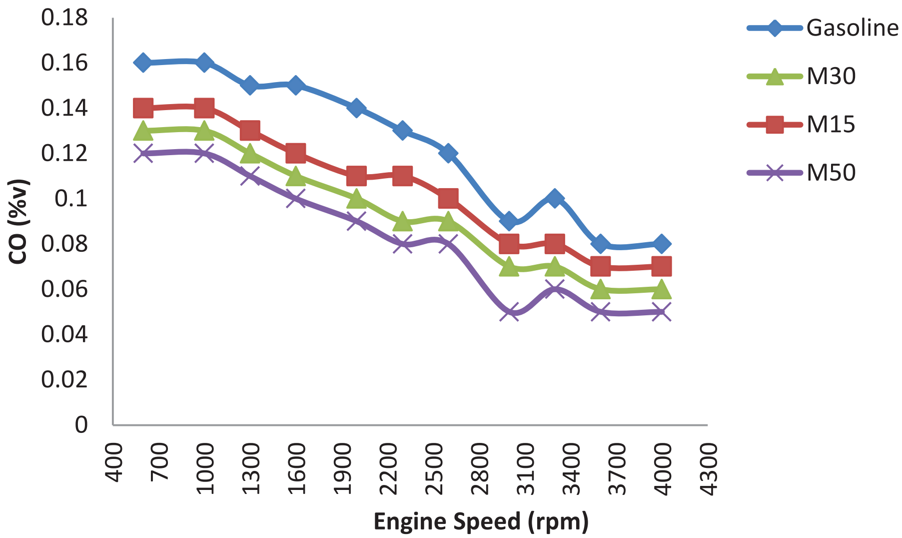

Figure 3. The effect of addition methanol on the CO emission

3. CO2 Emission

The effect of the methanol–gasoline blends on CO2 emission for different engine speeds is shown in Fig. 4. The graph showed that when methanol percentage increases, the concentration of CO2 emission increase. On the other hand while the engine speed is 3300 above the CO2 emission is decrease.

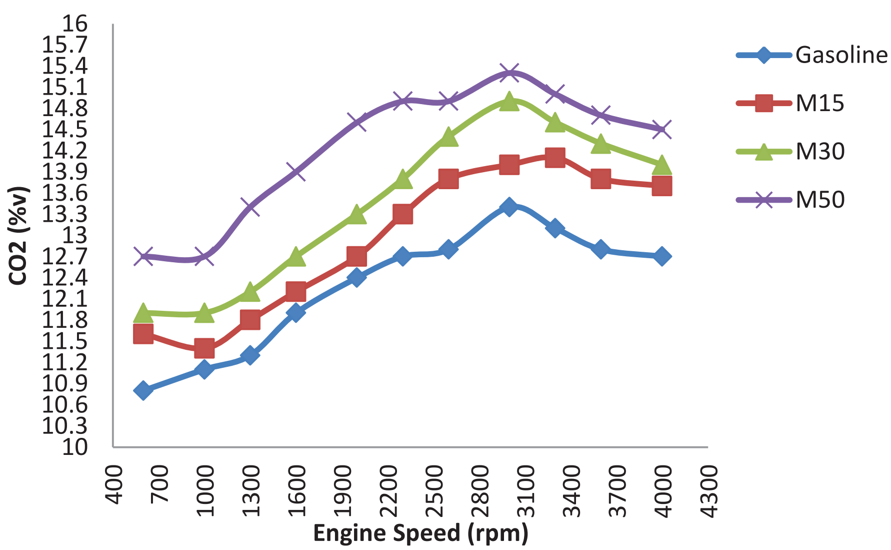

Figure 4. The effect of addition methanol on the CO2 emission

4. HC Emission

The effect of the methanol–gasoline fuel blend on HC emission for different engine speeds is shown in Fig. 5. The graph showed that when methanol percentage increases, the concentration of HC emission decreases. The concentration of HC emission decreases with increase of the relative air-fuel ratio, the reason for the HC concentration decrease is similar to CO emission described above.

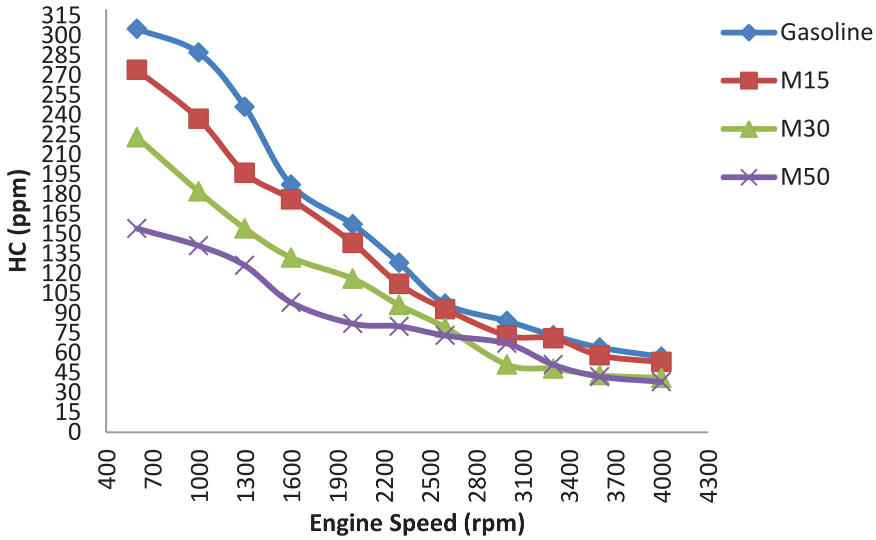

Figure 5. The effect of addition methanol on the CO2 emission

CONCLUSION

In this study, it appears that when the engine using methanol-gasoline fuel blend, the fuel consumption is relatively decrease. Each of these reductions in fuel consumption for the M15, M30, and M50 are 9.5%, 7.2% and 3.1% respectively. this shows that the use of methanol-gasoline fuel blend can slightly reduce fuel consumption. Since the latent heat of evaporation of methanol is higher than that of gasoline, during compression process, the fuels containing methanol will absorb more heat from combustion chamber and eventually, the pressure of the combustion chamber will be decreased accordingly. Relying on above statements, during the compression process, the pressure of such combustion chamber will be decreased compared with when pure gasoline is used in combustion. Using methanol-gasoline fuel blend able to decrease emissions of HC and CO, respectively by 45% and 33.25%, while the CO2 emissions increased by 10.3% for all engine speeds.

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