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Effects of Ethanol-Methanol Fuel on RPM and Exhaust Gas Generator Set

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ABSTRACT

This study aims to determine the effect of ethanol-methanol fuel on long fuel consumption, and the effect of loading on generator set rpm, Carbon Monoxide (CO), Carbon Dioxide (CO_2), and HC generator set exhaust emissions. The test uses a General ET 2500 C generator set, a maximum output power of 1200 watts, and current output. The fuel used is G100, E100, E 75+M25, E50+M50 , E25+M75 and M100. The results of the tests carried out show that increasing the load causes the generator RPM to decrease, the most significant decrease in RPM when using M100 fuel. Among the most economical fuel variations is using the E25+M75 fuel variation. The type of fuel is not affected by voltage or amperage. The last increase in CO is using E-100 fuel, the smallest CO emission is 2.12% using E-100 fuel with a load of 100 watts. Testing the generator set loading 100 watts obtained the highest HC of 988 ppm, and when loading 500 watts the highest HC was 1161 ppm. The CO_2. level at 100 watts loading was 12.4% using E75+M25 fuel, at the largest 500 watts CO_2 loading was 9.3% using E100 fuel.)

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1.0 INTRODUCTION

An increase in population density increases the demand of fuel consumption. Air pollution resulting from the release of harmful substances into the air by vehicles and factories are the world major problems [1][2]. Gasoline fuel is increasingly depleting its reserves in almost all countries in the world, and dependence on fuel derived from petroleum is very high. The highest use of gasoline is in the transportation sector where internal combustion system produces mechanical energy through burning fuel in the combustion chamber [3][4]. The incomplete combustion of fuel in the combustion chamber results in air pollution[5] [6]. Air pollution caused by incomplete combustion of fuel in the combustion chamber can interfere with human health and cause air pollution[7] [8].

Efforts to replace fuel from petroleum with renewable fuels are continue to be carried out. Renewable fuel derived from biomass is one of the alternative energy sources that continue to be developed in research or as a mixing material [9] . Ethanol can be produced from the fermentation of glucose contained in biomass and aqueous solutions, examples of biomass containing glucose are sugarcane, corn, and cassava [9][10] [11]. Ethanol has a reasonably high octane number, namely 106 to 110 [12][3] . Ethanol also has a higher heating value than gasoline [4][13]. Therefore, it is very suitable to be used as fuel for gasoline engines. Due to high octane value, ethanol also increase energy efficiency since ethanol has higher heat of vaporization than gasoline [11][14].

One of the main attributes for complete combustion is the heat of vaporization of the fuel and the speed at which the fuel burns. So that the higher ethanol content in the fuel mixture and the high engine RPM cause the CO and HC exhaust gas content to decrease, and CO_2 exhaust emissions to increase [15]. Ethanol can be used as a component of diesel fuel mixtures even though it has a small cetane number [8] [16]. Another form of alcohol besides ethanol is methanol. Methanol is a type of alcohol that can be obtained at a lower price but has high toxicity [1][17]. Methanol is an alcohol that is simpler than ethanol, methanol has a methyl group connected to a hydroxyl group with the compound formula CH_3OH [13][12] while ethanol consists of an ethyl group linked to a hydroxyl group the compound formula is C_2H_5OH [12][7][13].

Methanol has a lower heating value of 20.1 MJ/kg[13][18] than ethanol of 26,8 MJ/kg[9] [13]. Due to the problems of gasoline fuel originating from petroleum, among others, the depletion of fossil fuels and the problem of air pollution, and several advantages of alternative energy from biomass, namely methanol, and ethanol. What is more interesting is the use of methanol as a fuel, which has a lower price than ethanol, which is very interesting to study for power generation. Power plants use a generator set using a gasoline engine, the gasoline engine used requires fuel with a high octane number, high ignition temperature, and low cetane number to work. The octane number, high ignition temperature, and cetane of ethanol are 108-110 [12], 425 °C [12], and 0-8 [13][16]. The octane number 108.7, ignition temperature 423 °C, and cetane number of methanol are 5 [19].

Tabel 1: Physicochemical properties of methanol, ethanol, and pure gasoline [12].

Propertis	Gasoline	Methanol	Ethanol
Chemical Formula	$C_{5-10}H_{12-22}$	CH_3OH	C_2H_5OH
Carbon Mass (%)	87,5	37,5	52,2
Hydrogen (%)	12,5	-	34,7
Oxygen mass (%)	0	49,93	34,7
Boiling Temperatur (^oC)	27-225	78	78,25
Research Octane Number, RON	90-100	108,7	108,6-110
Flash point (^oC)	-45 to-13	11	12-20
Auto ignition Temperatur (^oC)	257	423	425

Both methanol and ethanol can be used in gasoline engines. There are two things that need to be considered when using methanol or ethanol in gasoline engines, namely the calorific value and the air-fuel ratio. Compared to gasoline, ethanol has a lower heating value. During combustion, ethanol requires much less air than gasoline, which is 9 and 14.7 [11] [17], respectively. The purpose of this study was to investigate the performance of the generator engine and the cost of electricity using an ethanol-methanol mixture as fuel.

Moreover, it is interesting to learn more about strategies for increasing efficiency and reducing power generation costs.

2.0 EXPERIMENTAL PROCEDURE

2.1 Experimental Engine Set Up

The generator engine consists of an internal combustion engine motor and an electric generator. The function of an electric generator is to convert fuel energy into electrical energy. The motor converts fuel energy into mechanical energy, then the generator converts mechanical energy into electrical energy. The type of generator set used for testing is shown in Table 2. The model was General ET 2500 C type 1 cylinder 4 stroke, engine oil capacity was 600 cm^3 and the maximum output power was 1200 W. The compression ratio was 8.5: 1. The current output from the generator has an AC voltage of 220 V with a frequency 50 Hz. Performance considered is efficiency and specific fuel consumption. The load varies from 100 W to 500 W, loading using a light bulb connected to the generator set.

Table 2: Engine Set Up Specifications

Model	General
Seri	ET 2500 C
Fuel	Gasolin
Rate Votage	220 V
Rate Frequency	50 HZ
Fuel System	Carburetor
Rate AC Output	1150 Watt
Max AC Output	1200 Watt

The load circuit consists of a series of light bulbs as a load arranged in parallel and several switches. The installed bulb consists of 5 bulbs of 100 W each. The digital multimeter is placed between the machine and the load. This tool can measure power, energy, voltage, and current using a digital multimeter. The fuel tank is equipped with a volume meter to determine the amount of alcohol used during combustion. Alcohol enters the combustion chamber to be converted into mechanical energy, then the generator converts the motion energy into electrical energy. The electrical energy is loaded in the form of a light bulb variation. The data required and must be measured are the current (A) and voltage (V). Exhaust emission testing using QROTECH-401 Automotive Emission Analyzer, for testing CO, HC, and CO_2 exhaust gases from the generator set. RPM generator reading using the WIPRO RPM Meter. Tests using gasoline fuel, 96% ethanol, and methanol purchased at a chemical store.

2.2 Fuel Used Test

Fuel is measured, and the volume is 50 CC each. The fuel variations are as follows: 100% gasoline (G100), 100% ethanol (E100), 75% ethanol + 25% methanol (E 75+M25), 50% ethanol + 50% methanol (E50+M50), ethanol 25 %+ methanol 75% (E25+M75) and 100% methanol (M100). The fuel consists of two types, each type is measured with a measuring cup and then mixed by shaking it slowly for a moment until the fuel is mixed. The concentration of these three types of fuel was shown in Table 3.

Table 3: Concentrations of gasolin, ethanol, and methanol

Test Blends	Volume of Gasolin (%)	Volume of Ethanol (%)	Volume of Methanol (%)
G100	100	-	-
E 100	-	100	-
E 75+M25	-	75	25
E50+M50	-	50	50
E25+M75	-	25	75
M 100	-	-	100

The data collection process is as follows. First, the arrangement of the equipment according to the scheme in Fig 1. The next step is to turn on the generator without load with gasoline, for preheating and to find out whether there are problems or not in the generator set. The fuel is inserted into the fuel tube according to its variation and size, the generator set is connected to a load source in the form of a lamp with variations of 100 watt, 200 watt, 300 watt, 400 watt, and 500 watt. Each fuel variation for testing is 50 CC.

Fiqure 1: Schematic diagram of experimental set up.

3.0 RESULTS AND DISCUSSION

Figure 2 shows the effect of the load in the form of a lit lamp on the generator rpm. The generator RPM is very influential on the work of the generator set. The engine generator rpm drops in all variations of fuel due to the addition of a given load. If the applied load is excessive, it will reduce the rpm of the generator set due to the size of the fuel limit. If the maximum fuel limit is reached the generator set such as reducing the intake of air through the filter or fuel and finally not getting full power to get the rpm like a generator with no load[20] [21]. Combustion in the cylinder will be poor due to lack of oxygen or fuel to maintain rated speed. With increasing load, engine speed will decrease [5]. The decrease in rpm of the generator set for G 100 fuel with 100 Watt and 400 Watt loading is 30.41%. Testing loading of 100 watt and 400 watt using E 100 fuel decreased rpm by 35.34%, E75+M25 fuel decreased rpm by 29.54%, E50+M50 fuel decreased by 33.50 %, fuel E25+M75 decreased rpm by 28.88 % and fuel M100 rpm decrease by 35.51%. The biggest decrease in rpm with increasing load is M100 fuel, and the smallest uses E25+M75 fuel.

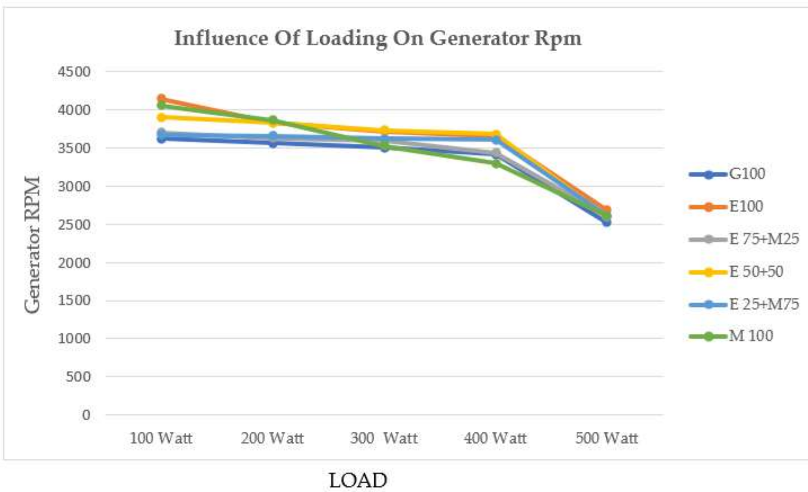

Figure 2: Influence of loading on generator rpm

Figure 3 demonstrates the effect of the duration of ignition of the generator set with the amount of fuel as much as 50 CC, variations in fuel G 100, E100, E75+M25, E50+M50, E25+M75, and M100. From all the variations of the tested fuel, it shows that the fuel consumption time is getting shorter, as the load on the generator set increases [4][21]. Time for ignition of 50 CC fuel generator set G100 with the loading of 100 watt and 400 watt decreased fuel consumption by 29.71%. Testing fuel consumption with the loading of 100 watt and 400 watt, fuel E 100 decreased fuel consumption by 14.4%, with the same test using fuel E75+M25 decreased fuel consumption time by 17.16%, testing using fuel E50+M50 decreased fuel consumption is 27.04%, testing using E25+M75 fuel reduces fuel consumption by 33.83% and testing using M100 fuel decreases fuel consumption time by 14.06%. The biggest decrease in fuel consumption with increasing load is E25+M75 fuel, and the smallest uses M100 fuel.

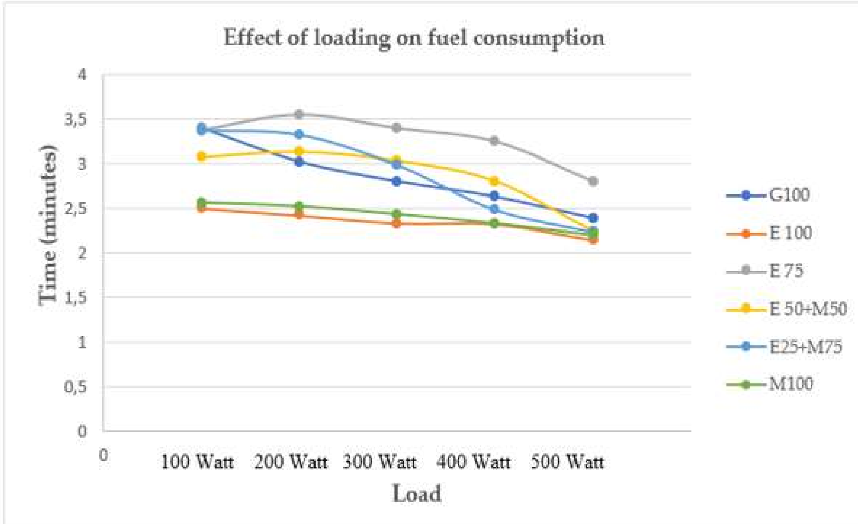

Figure 3: Effect of loading on fuel consumption

Table 4 shows the result of testing of generator set using six variations of fuel with variations in lamp loading. The results can be seen that the fuel is not affected by voltage or electric current. In every variation of fuel and loading, the results are almost the same, there are no significant changes. Current strength is not affected by the initial rotation speed of the engine but is affected by the power applied to the generator set [2].

Table 4: Electric V(volt) and I (Ampere)

	G100		E 100		E 75+M25		E50+M50		E25+M75		M100	
	V	I	V	I	V	I	V	I	V	I	V	I
100 Watt	222	0.9	222	0.9	222	0,9	222	0,9	222	0,9	222	0.9
200 Watt	221	1.7	221	1.7	222	1,7	221	1,7	221	1,7	221	1.7
300 Watt	221	2.6	221	2.6	221	2,6	221	2,6	220	2,6	221	2.6
400 Watt	220	3.4	220	3.4	220	3,3	219	3,4	220	3,3	220	3.3
500 Watt	220	4.2	220	4.2	220	4,0	219	4,1	220	4,1	220	4.2

Figure 4 explains the effect of loading variations on CO exhaust emissions. The fuel used produces CO with different concentrations increasing. The increase in CO per fuel due to the engine generator set when the load increases the engine speed decreases, and reduced engine speed results in a reduced supply of oxygen from free air. Reduced oxygen supply results in incomplete combustion. Incomplete combustion results in the formation of high levels of CO in the exhaust gas [4][22][23]. But if the RPM is high, the level of CO in the exhaust gas emissions decreases [17][23][24].

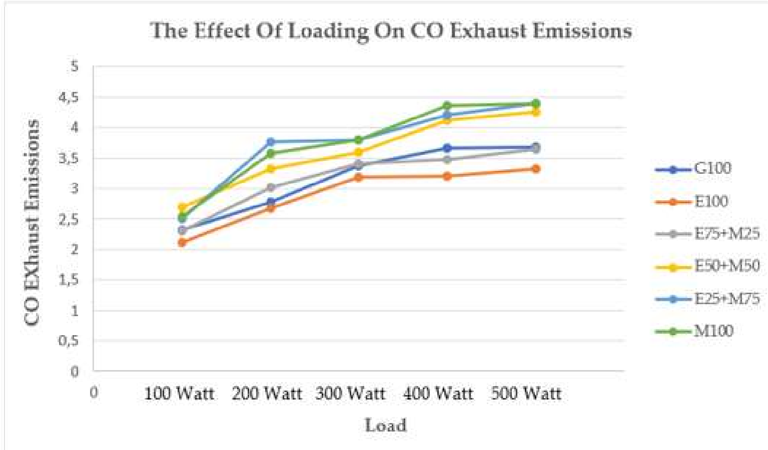

Figure 4: The effect of loading on CO Exhaust emission

The generator set uses G100 fuel when loaded with 100 watts and 500 watts of CO exhaust emissions increased by 58.62 %. The generator set uses E100 fuel when loaded with 100 watts and 500 watts of CO exhaust emissions increased by 56.60%. The generator set uses E25+M75 fuel when loaded with 100 watts and 500 watts of CO exhaust emissions have increased by 58.70%. The generator set uses E50+M50 fuel when loaded with 100 watts and 500 watts of CO exhaust emissions increased by 57.41 %. The generator set uses E25+M75 fuel when loaded with 100 watts and 500 watts of CO exhaust emissions increased by 75.6%. The generator set uses M100 fuel when loaded with 100 watts and 500 watts of CO exhaust emissions increased by 73.33%. The last increase in CO is using E100 fuel, the smallest CO emission is 2.12% using E100 fuel with a load of 100 watts, and the allowable CO emission limit is 2.1% -2.7% [25].

Fig 5 explains the HC content in high exhaust gases at low rpm, all variations of fuel, the HC content decreases, due to incomplete combustion. The fuel is trapped in a narrow gap in the combustion chamber due to the quenching effect on the cylinder wall, the fuel coming out of the combustion chamber is still in the form of hydrocarbons along with the remaining combustion gases in the vehicle exhaust [26]. The higher the engine speed, the smaller the HC content, because when the engine speed is high, the combustion chamber temperature increases. The high combustion chamber temperature causes the fuel and air mixture to be more flammable and eventually the HC content will decrease as the vehicle engine rpm increases [1]. The generator set uses G100 fuel when loaded with 100 watts and 500 watts of HC exhaust emissions increased by 57.17%. The generator set uses E100 fuel when loaded with 100 watts and 500 watts of HC exhaust emissions increased by 23.30%. The generator set uses E25+M75 fuel when loaded with 100 watts and 500 watts of HC exhaust emissions increased by 40.6%. The generator set uses E50+M50 fuel when loaded with 100 watts and 500 watts of HC exhaust emissions have increased by 17.51%. The generator set uses E25+M75 fuel when loaded with 100 watts and 500 watts of HC exhaust emissions increased by 29.33%. The generator set uses M100 fuel when loaded with 100 watts and 500 watts of HC exhaust emissions have increased by 19.85 %. Testing the generator set with 100 watts loading, the highest HC is 988 ppm, and when loading 500 watts, the highest HC is 1161 ppm.

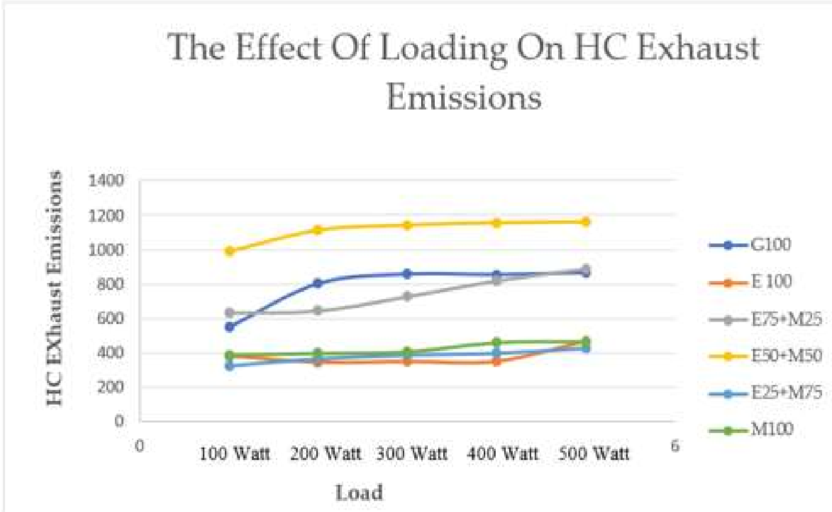

Figure 5: The effect of loading on HC exhaust emission

Figure 6 describes the effect of the generator set load on CO_2 exhaust emissions, using the fuel variation test. From the test, the results show that all variations of fuel show that CO_2 exhaust emissions decrease when added to the load. The generator set uses G100 fuel when loaded with 100 watts and 500 watts of CO_2 exhaust emissions have decreased by 36.07%. The generator set uses E100 fuel when loaded with 100 watts and 500 watts of CO_2 exhaust emissions have decreased by 29.71%. The generator set uses E25+M75 fuel when loaded with 100 watts and 500 watts of CO_2 exhaust emissions have decreased by 35.40%. The generator set uses E50+M50 fuel when loaded with 100 watts and 500 watts of CO_2 exhaust emissions decreased by 33.63%. The generator set uses E25+M75 fuel when loaded with 100 watts and 500 watts of CO_2 exhaust emissions have decreased by 34.81%. The generator set uses M100 fuel when loaded with 100 watts and 500 watts of CO exhaust emissions have decreased by 31.82%. The level of CO_2 at 100 watts loading is 12.4% using E75+M25 fuel, at 500 watts loading the largest CO_2 is 9.3% using E100 fuel.

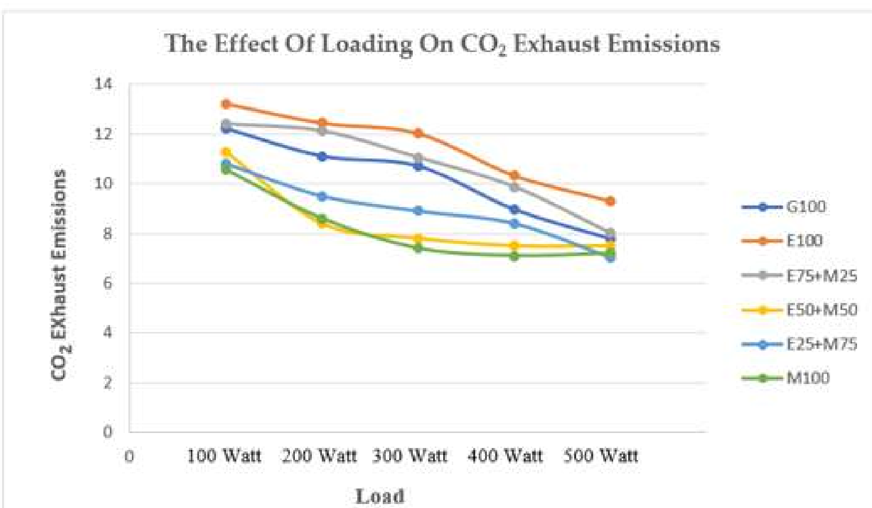

Figure 6: The effect of loading on CO_2 exhaust emission

4.0 CONCLUSION

The results of the generator set test using variations in fuel and loading was obtained as follows; the largest decrease in rpm with increasing load was M100 fuel, and the smallest uses E25 + M75 fuel. The biggest decrease in fuel consumption with increasing load is E25+M75 fuel, and the smallest uses M100 fuel. The type of fuel is not affected by voltage or electric current. In every variation of fuel and loading, the results are almost the same, there are no significant changes. Current strength is not affected by the initial rotation speed of the engine but was affected by the power applied to the generator set. The last increase in CO was using E100 fuel, the smallest CO emission was 2.12% using E100 fuel with a load of 100 watts. For testing the generator set with 100 watts loading, the highest HC was 988 ppm, and when loading at 500 watts, the highest HC was 1161 ppm. The level of CO_2 at 100 watts loading was 12.4% using E75+M25 fuel, meanwhile at 500 watts loading the largest CO_2 was 9.3% using E100 fuel.

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