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Effect of Water/Methanol and Water/Ethanol Injection Systems on Performance and Emission Motorcycle 110cc

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Abstract

This research presents an additional injection system that is in the motorcycle intake manifold. In this system the position of additional injectors parallel to the intake manifold and lead to the fuel chamber. This system serves to change the liquid in the form of a mixture of water/methanol or water/ethanol with pressure 400 kPa to turn the shape into a fog and spray 15% mixture into the fuel chamber. The purpose of this research is to know the effect of additional injection systems on performance, exhaust emissions and motorcycle fuel consumption. The research uses experimental methods, used to conduct live trials of systems and samples: AM10, AM30, AM50, AE10, AE30, AE50, H2O and STD. The test results showed the highest torque found in the AE50 sample was at 5.86 Nm up by 6.7% and the highest power of 5.7 HP rose 9.6% compared to vehicle conditions without AM and AE injection. The results of the emission test of the motorcycle vehicle using the AM and AE injection system showed an HC value down by 90% found in the sample AE10, in gas CO also reduced by 69.7% found in the samples of H_2O and AE10, then the O_2 gas value decreased by 80% Found in the sample AM50 and CO_2 are at a value of 14.50% in the sample AE10. The lowesst fuel consumption found in STD samples amounted to 320 ml per 15 km

Key-word: - Water / Methanol Injection; Water / Ethanol Injection; Water Injection System; AE and AM injection.

1. Introduction

With the growth of motorcycle vehicles of around 10% per year in Indonesia, it has become one of the king of the streets in major cities in Indonesia. The number of motorcycle sales in Indonesia reached 5.8 million units in 2017[1]. One thing that is directly related to this is the problem of air pollution and rising air temperatures. This is directly proportional to the producer of air pollution, the increase in temperature and the biggest use of fuel oil are two-wheeled motor vehicles. Air pollution that causes global warming, increased temperatures and scarcity of fuel oil is what drives the government as a regulator, as well as the public as users begin to think to reduce these adverse effects by creating various innovations how to reduce the impact of pollution caused by motor vehicles, especially motorbikes this is at the same time how to improve the efficiency of the vehicle itself so that it becomes better and environmentally friendly. Utilization of technology in motorcycles will be one solution to reduce the impact of air pollution and improve motorcycle performance. So that technological developments in vehicles heading towards environmentally friendly with various regulations issued by the government, such as conducting vehicle emission tests and making the exhaust emission threshold lower.

One innovation that is starting to develop now is the use of water injection systems in vehicles. In internal combustion engines, water injection, also known as anti-detonant injection, is a method for cooling the engine's combustion chamber by adding water to the cylinder or entering a fuel mixture, generally aiming for a greater compression ratio and basically eliminating knock problems[2]. Water Injection is not something new, this technology has existed since 1920 almost a century ago. Many technologies that were originally developed for military or space use were later adapted for more general use. This water injection rose to prominence during World War II[3]. In 2015 BMW has introduced a M4 coupe version of their high performance M4 GTS which combines water injection with intercooling. The car appeared in the 2015 MotoGP event as an official safety car for the series and was released to the commercial market in 2016. Bosch, which developed this technology, offers a water injection system named WaterBoost for other manufacturers. The company claims a 4% increase in engine performance, a reduction in CO2 emissions of up to 4% and an increase in fuel savings of 13%[4]. The optimal ratio of water injection at a value of 15% to the mass of the fuel, this results in improved engine performance and emissions (including NOx, CO2, HC and soot) NOx emissions have decreased by 34.6% [5]. This system functions to inject the converted water into the form of mist and channel it into the combustion chamber so that perfect combustion occurs thereby reducing harmful gas emissions. Fuel efficiency with water injection increases by up to 20% when the engine is operated when the throttle valve is fully open. At the same time an increase in power of more than 4% was achieved compared to operations without water injection[6].

Various types of water injection systems with varying models including the indirect water injection system using a type of direct injection system engine. Then the model of a water injection system with a spray directly into the engine and using a type of direct injection engine shows the results of increased engine performance due to increased pressure and effective efficiency which is shown from the cooling results of certain engine parts. Water injection also shows reduced vehicle emissions[5]. Other water injection system models are by direct water injection and using indirect injection machines. The result of the addition of water injection reduces the possibility of knocks at an engine load of 90 Nm and at an engine speed condition of 2000 rpm and when spark plugs are advanced can also directly increase BSFC results[7]. The model of indirect water injection system and using indirect injection engine with this system shows the fuel efficiency with indirect water injection can increase up to 20% when the engine is operated when the throttle valve is fully open. At the same time an increase in power of more than 4% was achieved compared to operations without water injection [6].

Another potential benefit of injection of a water / methanol mixture rather than an injection of only water is a faster-than-expected evaporation rate. This is an interesting perspective to overcome the difficulty of evaporation experienced by water injection at low rpm conditions [8]. The use of this system has actually been carried out by various modifiers, it's just that its application on car vehicles to improve performance for racing and experimental research on this system is still minimal, especially applications on motorcycle vehicles. Some of the journals that exist mostly discuss this system, but its application in four-wheeled vehicles while for motorcycles themselves are still rare. So that researchers are challenged to be able to apply this system to motorbikes but by adding a mixture of water with methanol or ethanol to produce more complete combustion and improved performance. With the addition of methanol or ethanol to water injection is expected to get a more maximum effect in the combustion process and is expected to be a solution in water injection systems that are difficult to evaporate at low rotation [8].

2. Research Methods

The method used is an experimental method in which this method will test the increase in performance and emissions of motorcycle exhaust using a water/methanol and water/ethanol injection system with a different percentage of the mixture. And will test motorcycle fuel consumption. The experimental research method can be interpreted as a research method used to look for the effect of certain treatments on others under controlled conditions[9].

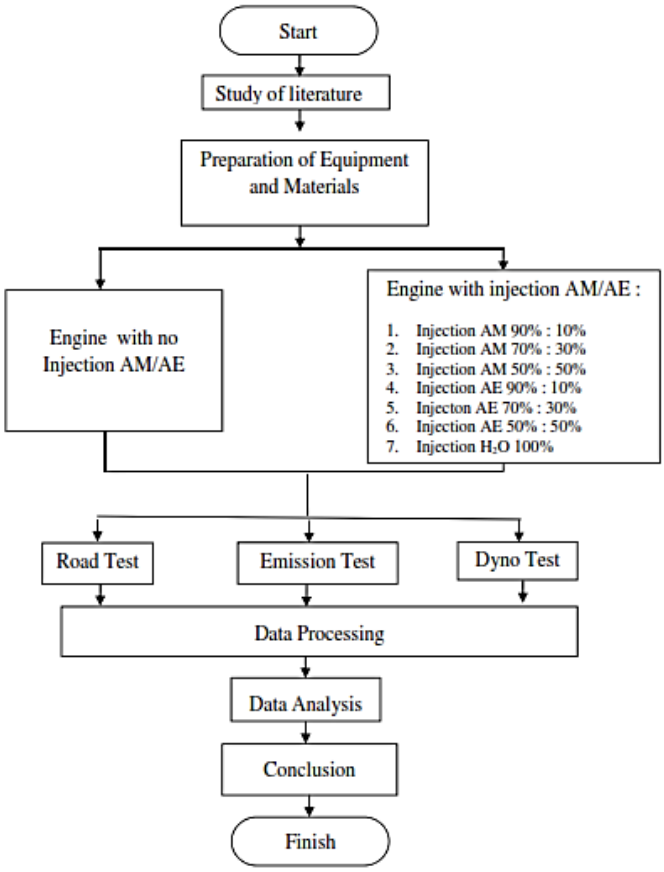

Figure 1. Detailing Scheme

In addition to the fossil fuels that are used today that are available from the bowels of the earth, many countries make rules by adding fossil fuels with biofuels such as methanol and ethanol mixed with fossil fuels to get maximum results and are more environmentally friendly. Blends are provided with various comparisons of variations between fossil and vegetable fuels. This mixture is expected to get a more complete combustion so as to produce exhaust emissions as minimal as possible so that it can reduce the environmental impact. The following table compares fuel data used in mixtures.

Table 1. Comparison of Fuel Data [10]

Properties	***Gasoline***	***Methanol***	***Ethanol***
Chemical Formula	C_8H_{18}	CH_3OH	C_2H_5OH
Molecural Weight (g/mol)	95-120	46,07	32,04
Density (g/cm3 at 20ºC)	0.72–0.76	0.790	0.792
Latent heating value (kJ/kg)	44300	26900	20100
Stoichiometric air/fuel ratio	14.6	9	6,46
Oxygen (% wt)	-	34.73	49.94
Research octane number	95	108.6	108.7
Motor octane number	85	89.7	88.6

Auto-ignition temperature (ºC)	228–470	363	455
Boiling point (ºC)	27–225	78.3	64.5
Vapor pressure (kPa at 20 ºC)	45–90	5.9	12.8
Heat of vaporization (kJ/kg)	349	923	1178
Flammable Limits (% vol.)	1.4–7.6	3.5–15	5.5–36.5

The treatment given in this study was the use of a water/methanol or water/ethanol injection system on a motorcycle, with a water/methanol or water/ethanol injection volume of 15% of the volume of fuel injected into the combustion chamber with idle engine conditions ie less rotation over 1700 rpm and the system starts working at 4000 rpm with an injection pressure of 400 kPa. This shows that the independent variable in this study is the use of a water injection system water/methanol and water/ethanol with a different percentage of the mixture with a comparison of the percentage injection mixture of water/ methanol and water/ethanol that is Water 90%: Methanol 10% (AM10), Water 70%: Methanol 30% (AM30), and Water 50%: Ethanol 50% (AM50), and Water 90%: Ethanol 10% (AE10), Water 70%: Ethanol 30% (AE30), and Water 50%: Ethanol 50% (AE50), and water or 100% H_2O (H_2O). The dependent variable in this study is engine performance through power, fuel consumption and torque data as well as exhaust gas emissions resulting from the test results of the vehicle in the form of HC, CO, CO_2 and O_2 gases. Retrieval of emission data using the HG-520 gas analyzer and for power and torque using dynotest from sportdevices as well as road testing of motorcycle vehicles.

Injection System Installation

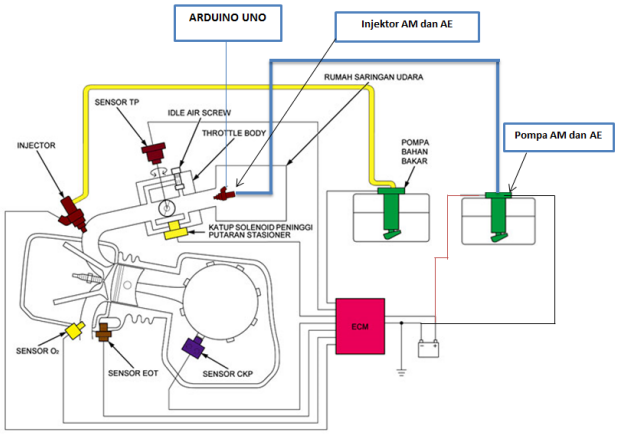

Figure 2. Injection system Installation Scheme

Figure 2. it can be seen the position of the AM and AE injectors leads straight towards the throttle valve so that the spray can lead directly to the combustion chamber. AM and AE injectors are mounted on a motorcycle intake manifold that has been previously modified so that it can be easily sprayed directly into the combustion chamber. The amount of spray is regulated by Arduino Uno by sending a signal to the injector in accordance with the pre-set duration. This injection system works at 4000 rpm which is regulated by a manual switch based on the throttle valve opening. AM and AE pumps that function to raise the pressure up to 400 kPa are in a ready condition when the ignition is ON. The tank containing a mixture of methanol/water or ethanol/water and AM and AE pumps is in the trunk of a motorcycle.

3. Results and Discussion

Research results obtained from testing machine performance using a computerized system are in the form of data tables and graphs so that it can be easier in the process of data analysis.

Torque and Power Results

After taking data using dynotest from Sportdevices, the highest torque results were found in the AE50 sample at 5.86 Nm at 6500 rpm. This value is not so much different from the AM50 sample with the highest torque found at 5.82 Nm at 6500 rpm. This shows the increase in torque produced in samples that have a large mixture ratio of methanol or ethanol. The highest power results were found in the AE50 and AM50 samples at 5.7 HP at 8700 rpm and at 8000 rpm. The result of increased torque and power is influenced by the amount of methanol and ethanol added to the mixture, the more methanol or ethanol that is mixed, the more the torque and power produced. This is because methanol and ethanol are fuels other than premium. This also causes an increase in the compression ratio of the engine due to additional fuel entering the combustion chamber, causing the possibility of greater knocking on the engine so that in this condition the water in the mixture occurs preparation and absorbing heat to reduce the temperature of the combustion chamber so as to avoid the occurrence knocking on the engine.

2. Emission Test Results

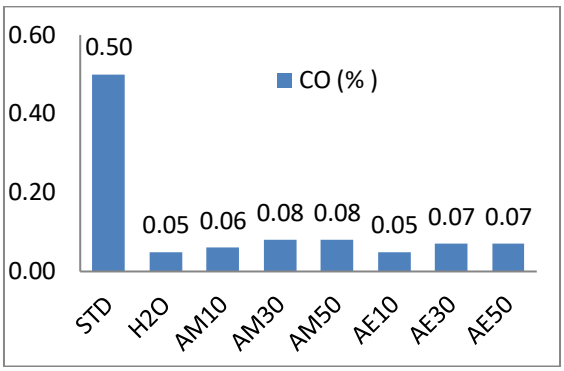

Figure. 3. CO Gas Emissions test result

Based on picture 3. the difference in the amount of CO gas from the test results of some samples that use AM and AE injection is very small, in the range of 0.05% to 0.08% this value is very much lower than the CO value from the results of motorcycle emission tests without AM and AE injection treatment. From Figure 3. It can be seen that the effect of samples containing a mixture of water or H2O can reduce CO gas levels to the lowest value as in the H2O and AE10 samples with a value of 0.05% respectively decreasing by 90% compared to samples without injection treatment AM and AE. CO gas itself is formed as a result of residual fuel that is not combustible completely so that it comes out with combustion residual gas and can also be caused by a mixture of fuel that is too rich, which is a poor AFR ratio. Through these emission test results show that the fuel that is burned using the AM and AE injection system is better than without AM and AE injection.

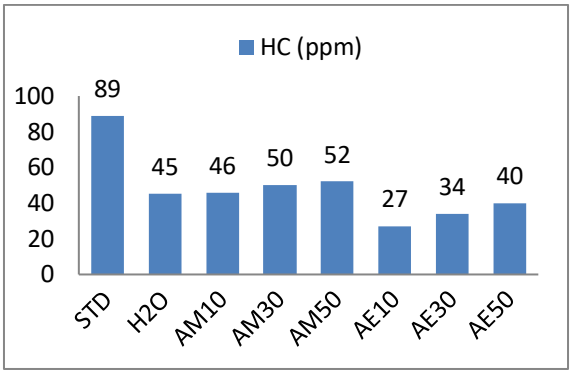

Figure. 4. HC Gas emission test Result

Figure 4. the STD sample is a vehicle sample without AM and AE injection treatment at 89 ppm. Whereas in the condition of motorbikes experiencing treatment using the AM and AE systems the HC value decreased significantly with the lowest value being in the AE10 sample of 27 ppm reduced by 69.7%. This is influenced by the addition of water or H2O in each sample. The same thing happened in other samples using a mixture of methanol or ethanol which experienced a decrease of less than 50% compared to samples without AM and AE injection. Figure 4 shows the amount of water or H2O affecting HC gas production in combustion and seen in ethanol mixture HC values have decreased very significantly. However, in the H2O sample with 100% injection of water the HC decrease was not as good as the mixture in the AE10 sample.

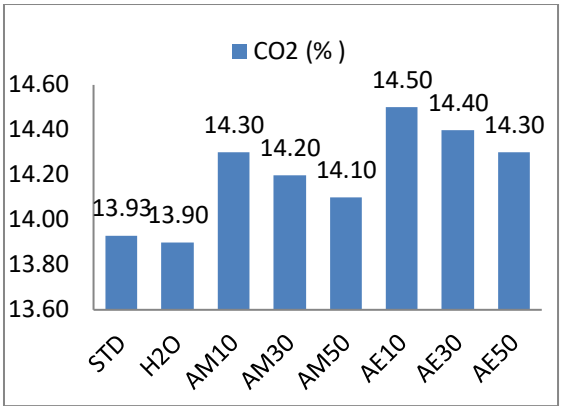

Figure. 5. CO2 Gas Emissions test result

Figure. 5. Shows the CO_2 gas on the motorcycle that does not undergo treatment i.e. the STD CO_2 emissions test results seen in the STD sample image are at a value of 13.39% This result is not much different from the sample of H2O is 13.93. The highest value of CO_2 is in the AE10 sample with a value of 14.50%. From Figure 5. We can also see the sample AM10, AM30 and AM50 experience an increase of CO2 value by 10% as the water or H2O improvement in the sample. The same is also the case with the sample AE10, AE30 and AE50 have increased the value of 10% as the water or H2O improvement in the sample. With the value of CO2 located at the number 14.50% indicates that the combustion inside the machine is very good and increasingly ideal it corresponds to the value of AFR in the sample AE10 is at the number 14.7.

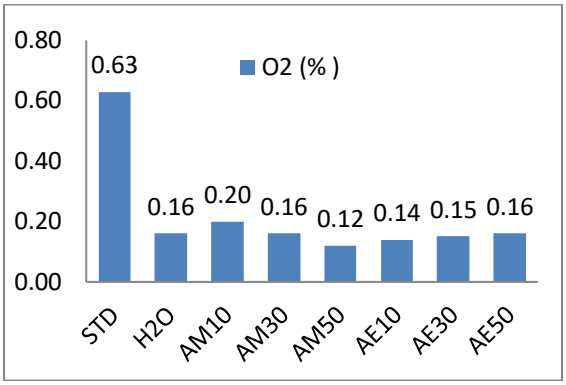

Figure 6. O_2 Gas Emissions test results

Figure 6. Visible value of O2 gases decreased significantly when using the AM and AE injection systems with a value range of 0.12% to 0.20%. This value is much lower than the samples without AM and AE injection with a value of 0.63%. The lowest value of O2 gas is in the AM50 sample with a value of 0.12%. From this result then can be said mixture of water/methanol and water/ethanol can decrease the O2 value wasted out because it is not burned. If the O2 exhaust gas value is closer to the value of 0%, the combustion process that takes place in the burn room is better as the O2 gas reacts and burns perfectly.

Fuel consumption result

Sample	Mix Type	Mixed Comparison (%)	Test Result	
			Mileage (km)	Fuel Consumption(ml)
AE50	H_2O/Etanol	50:50	15	340
AE30	H_2O/ Etanol	70:30	15	360
AE10	H_2O/ Etanol	90:10	15	380
AM50	H_2O/Metanol	50:50	15	350
AM30	H_2O/Metanol	70:30	15	360
AM10	H_2O/Metanol	90:10	15	370
H_2O	H_2O	100	15	380
STD	Premium	100	15	320

Table 1. Fuel consumption Road test results

Table 1. Visible results of the fuel consumption measurement of how many test samples conducted by means of the road test motorcycle vehicles on the road with a distance of 15 km and speed between 40-60 km/hour. These results indicate that the lowest fuel consumption found in STD samples is that the 15 km of treatment-less condition spent 320 ml of fuel and the highest fuel consumption found in AE10 samples with a mileage of 15 km Spent fuel of 380 ml. From the table it is also apparent that the addition of H2O on the sample increases the fuel consumption on the motorcycle.

4. Conclusion

1. The addition of methanol or ethanol in the sample affects the increased torque of this due to methanol and ethanol also functions as an auxiliary fuel, thereby increasing the pressure in the burn chamber. In the ethanol mixture, the sample AE50 experienced a torque increase of 6.74%. A similar thing also occurs in methanol mixtures with AM50 samples increased by 6.01%.
2. The addition of methanol and ethanol in the sample also affects the power increase. In the ethanol mixture with the AE50 sample and the ethanol mixture with the same AM50 sample – the same experienced a torque increase of 9.6%.
3. Based on the road test on the fuel consumption of STD samples or the untreatment conditions have the lowest fuel consumption among the samples – the other samples are 320 ml capable of a distance of 15 km. While other samples have increased Fuel consumption as you increase H2O or water on each sample.
4. The emission test results carried out on motorcycles using Heshbon Emission Gas Analyzer HG-520 showed very significant Gas changes in CO, HC, CO_2 and O_2. The decline in the highest CO value is 90% compared to the untreatment condition of H2O and AE10 is the sample with the lowest CO value of 0.05%. The best HC value reduction results in the AE10 sample with HC value = 27 ppm dropped 69.7% compared to the sample condition without treatment. The decline in O_2 value is also very significant which is 81% compared with the condition without treatment and the highest value of CO_2 found in the sample AE10 at 14.50%. Overall the emission test results experienced a positive response to the exhaust gas produced by the machine so that it can be concluded this additional injection system is able to lower gas CO, CO_2 and HC.

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