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Study of fuel efficiency and vehicle exhaust emissions with the addition of Pertamax Hot Steam Additives

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Abstract
One of the engine performance indicators, especially motorcycle engines, is fuel consumption and exhaust emissions. Measurement of fuel consumption using the drip burette method and exhaust gas analysis using a gas analyzer. This study discusses the use of additives as additives in fuel. Additive in the form of Pertamax vapor, which is heated and flowed to the intake manifold. The purpose of this research is to study fuel economy and the effect of exhaust emissions. The method used in this research is a survey, determination of survey variables, material preparation, tool adjustment, tool performance testing, data collection and reporting. The research was carried out step by step, namely the data collection process by testing the performance of the tool, setting the tool, and varying the percentage of gasohol. The results of this study are at 5000 rpm the highest consumption of pertalite is 9.82 ml/minute, the lowest consumption in the use of pertalite + pertamax steam heated at 4.36 ml/minute, there is a significant decrease in consumption of additives. the lowest CO content is pertalite fuel + pertamax steam heated at 0.95%vol at 1500 rpm, and the highest CO content is pertalite fuel at 4% vol at 3500 rpm. the lowest CO2 content is the use of pertalite + pertamax steam heated by 1% vol at 3500 rpm and the highest CO2 is 2%vol in pertalite fuel at 3500 rpm and 2%vol in pertalite fuel + Pertamax steam heated at 1500 rpm. Meanwhile, the lowest HC content is pertalite fuel + pertamax steam heated at 356ppm and the highest HC content is pertalite fuel at 3355ppm at the same engine speed at 1500 rpm.
Keywords : *additive, steam, heat, pertamax,*

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I. INTRODUCTION

Energy plays an important role in the course of civilization. The state of a country is positively correlated with its energy consumption. For example, the United States as the country with the highest Gross Domestic Product (GDP) in the world, which is USD 14,256,275 x 106, in 2009 consumed a total of 2,182 million tons of oil equivalent primary energy, which means 19.54 percent of the world's energy consumption. Meanwhile, the two giant economic powers in Asia, namely China and Japan, respectively consume 19.50% and 4.16% of the world's primary energy. Meanwhile, Indonesia consumes 1.15% of the world's primary energy. It is estimated that this increase will be even greater due to the need for fuel, as well as the increasingly limited fossil fuel (Bringezu et al., 2010). The limited domestic fuel oil encourages the government to implement a policy of energy diversification. This condition is based on Law Number 22 of 1999, Law Number 32 of 2004 concerning the Energy Sector and Presidential Decree of the Republic of Indonesia Number 5 of 2006 concerning National Energy Policy. Given the current global economic crisis, the development of alternative fuels needs to be increased (Balki & Sayin, 2014). Another step apart from seeking new and renewable energy is to increase the efficiency of fuel use. The increase in fuel efficiency must be accompanied by an increase in engine performance. Several steps that have been carried out in the field are the addition of additives..

Additives Additives are materials that are added to motor vehicle fuel, both gasoline engines and diesel engines. Additives are often referred to as fuel vitamins. Additives are used to enhance certain basic properties it already has, such as anti-detonation additives. gasoline to fuel gasoline engines and aircraft engines. Benefits of Additives to improve engine performance ranging from durability, acceleration to engine power. (Endyani & Putra, 2011)

The use of additives that are put into the fuel tank/mixed with fuel. The impact of adding additives in fuel aims to reduce exhaust gas emission compounds and increase engine performance, both torque and power. The addition of these additives was able to significantly reduce CO to 1,610, HC by 79.2 and eliminate Nox compounds, this was conveyed by Indah dwi Endyani. While the increase in fuel efficiency with the addition of natural additives, can improve the performance of 4 stroke motorcycle fuel usage r 33.91% for 5 minutes in a concentration of 1:8. (Saputra et al., 2013).

The addition of FFH Power Booster additives as a premium mixture in a 4 stroke engine can increase the amount of torque by 3.623%, the average power by 3.161%, while the increase in fuel efficiency can reach

4.092%. (Priyanto & Arif Batutah, 2017). On the other hand, Rosyida said the addition of an octane booster additive increased torque and power, reduced CO emissions to 0.08% vol, and decreased HC 129 ppm vol, thus affecting motorcycle performance and emissions. for the methanol-gasoline mixture. The results show improved engine performance, but improved fuel economy was found for all methanol-petrol mixtures. As far as engine emissions are concerned, this leads to significant reductions in CO and HC emissions. (Sharudin et al., 2017). The addition of oxidized ether additives to gasoline has the effect of reducing the toxicity of exhaust gases. Adding the right amount of additives (say 10%) can reduce the level of toxins in the fuel (Westphal et al., 2010). Adding methyl tertiary butyl ether and ethanol as fuel additives increases the environmental impact by 15.4%.(Yang et al., 2020), (Zaharin et al., 2018).

Research conducted by researchers is the addition of additives through the manifold in the afterfuel system (carburetor/injector). The question is the extent to which improved fuel economy and increased emissions will change. The purpose of this research is to find other solutions in the form of adding additives to the system other than the existing/developed system. Another purpose is to test the quality of the steam generator heater. The urgency of the research can be done through the fuel rail rather than adding additives directly to the fuel.

II. MATERIALS AND METHOD

A. Tools and materials

The tools used in this research are: :

1. Motorcycle

Machine parameters	Results
Step Volume	109.1 cc
Cooling System	Air
Ignition System	CDI
Lubrication System	Lubricating oils
Maximum Power	8.46 PS/7500 rpm
Maximum Torque	0.86 kgf.m/5500 rpm

2. Pertamax steam generator which has been designed with copper pipes as fuel line heaters.

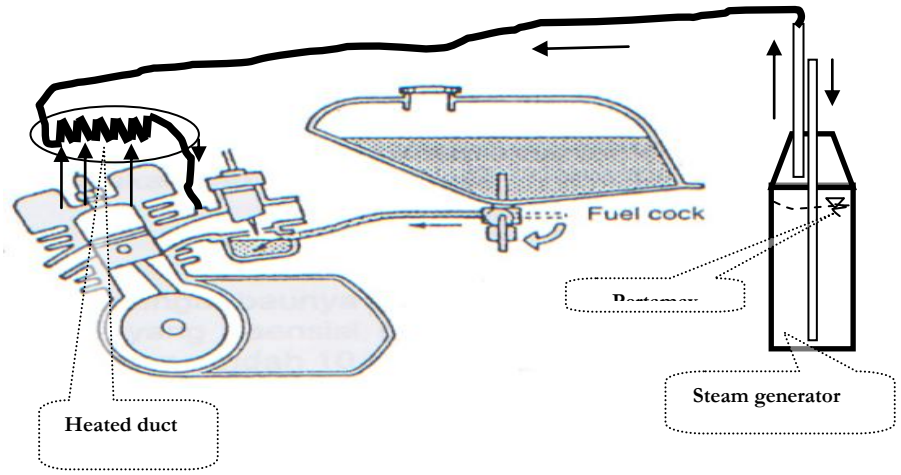

Figure 2. Schematic of tools and materials used

This system has a working principle using a fuel vapor system, where the fuel is fed into the steam generator, then the aircraft channel distributes the fuel vapor. Then the fuel vapor is channeled through a heating pipe or tube installed in the engine, so that the heating tube pipe can absorb engine heat. The steam that passes through the heating pipe is fed into the intake manifold through a rubber hose connected between the heating tube and the intake manifold, where the steam mixes with the fuel and air produced by the carburetor for the combustion process, which is then converted into power.

Figure 3 . Pertamax steam plane

3. Gas Analyzer.

Figure 4. Gas Analyzer

B. Test Method

The research methods carried out in this study are :

1. Addition of additives (heated pertamax steam) into the combustion chamber through the post-fuel system manifold (carburetor/injector). The concept of additives in the form of Pertamax fuel vapor is heated by utilizing engine heat which is fed through the intake manifold channel. This system is intended so that the hot gas steam pertamax will be consumed in combustion.
2. Manufacture of steam generator: designed by using a tank tube and then connected to the outlet pipe as the first steam outlet.
3. Tool performance test: testing by checking the tube and checking the pertamax steam pipeline, and installing the steamer to the motorcycle then starting the engine so that the engine is stationary.
4. Setting tools: installation of Pertamax steamer with rubber pipes and heating pipes.
5. The process of data collection.
   Retrieval of data on fuel consumption by using a burette and for exhaust emissions by using an exhaust gas analyzer in a sequence of steps :
   a. The engine is heated according to the working temperature of the engine.
   b. Observe each mixture tested within the fuel consumption rate indicated by the burette.
   c. Pay attention to the results of exhaust gas emissions produced by each mixture through the exhaust gas content analysis tool used.
   d. Observations and experimental data collection were carried out when testing each fuel mixture. The research data observed is the consumption of the fuel mixture and the content of exhaust emissions produced by each fuel mixture.
   e. The analysis was carried out to see the effect of the composition of the mixture of premium fuel and ethanol on fuel consumption and the content of exhaust gas emissions in the form of CO, CO2, HC.
   f. Conclusions are based on the results of data processing and analysis so that conclusions can be drawn regarding the composition of the fuel mixture that is most effective in fuel consumption and produces the best exhaust emissions. CO, CO2, HC.

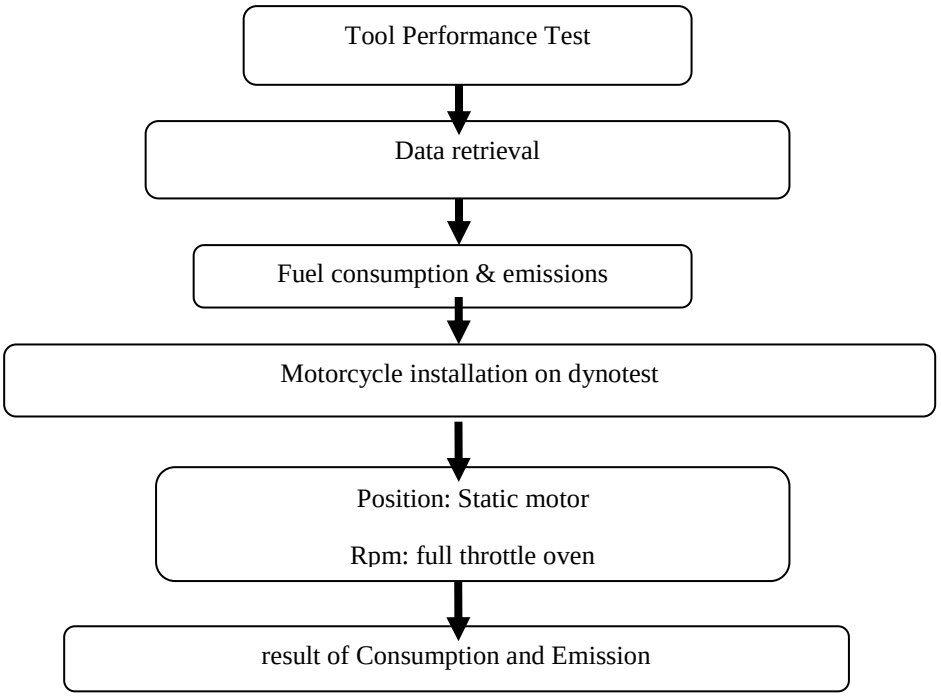

Figure 5. Stages of the data collection process

III. RESULTS AND DISCUSSION

A. Fuel Consumption

The results of motorcycle fuel consumption using pertalite, pertalite plus pertamax steam and pertalite plus heated Pertamax steam can be seen in table 2.

Table 2. Results of fuel consumption

rpm	Pertalite *ml/min*	Pertalite + Pertamax Steam *ml/min*	Pertalite + Pertamax steam heated *ml/min*
1500	2,6	2,04	2,04
2500	4,02	3,32	3,5
3500	4,64	4,08	3,92
5000	9,82	4,86	4,36

The test table shows the results of fuel consumption in ml/minute, each variant shows different achievements, with increasing rpm, an increase in fuel consumption is obtained. At 1500 rpm the lowest consumption was in the use of pertalite + Pertamax steam & the use of Pertalite + Pertamax steam was heated with the same result of 2.04 ml/minute. At 2500 rpm the lowest consumption was in the use of pertalite + pertamax steam of 3.32 ml/minute. At 3500 rpm the lowest consumption was using pertalite + Pertamax steam heated at 3.92 ml/minute and at 5000 rpm the lowest consumption was using pertalite + Pertamax steam heated at 4.36 ml/minute. It can be concluded that on average from various rpm's of rpm, the use of heated pertalite + Pertamax steam achieved the lowest use of fuel consumption, which means that the use of heated Pertalite + Pertamax steam had an effect on fuel consumption.

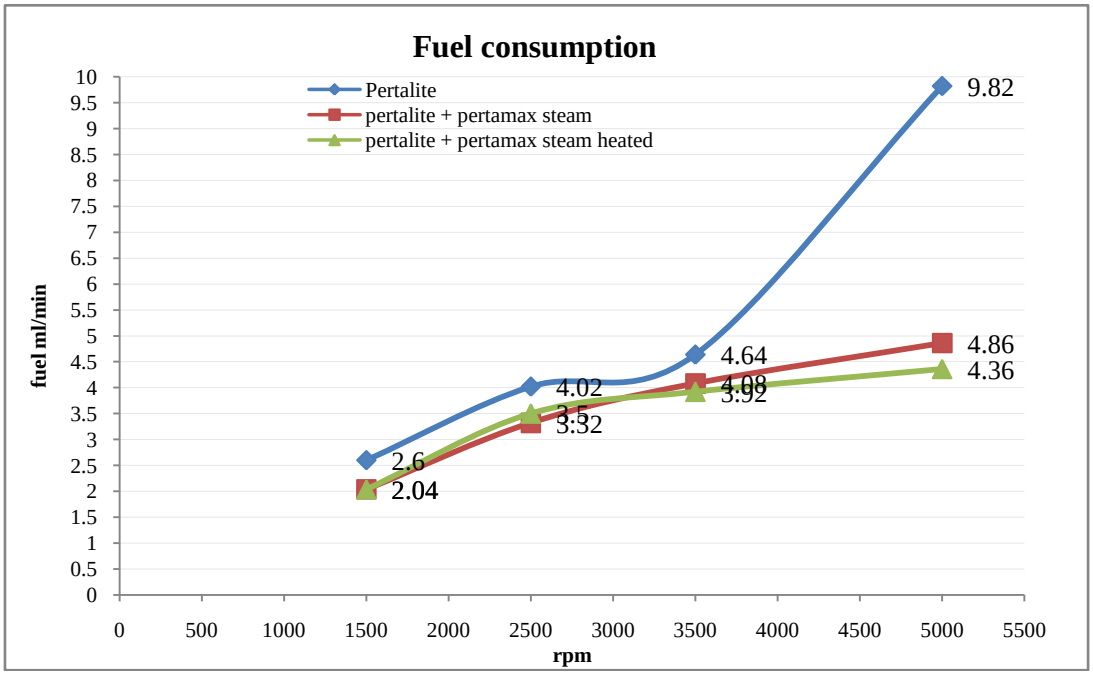

Figure 5. Graph of fuel consumption

The test graph shows the results of fuel consumption in ml/minute, each variant shows different achievements, with increasing rpm, an increase in fuel consumption is obtained. In the 1500 rpm chart the lowest consumption was in the use of pertalite + Pertamax steam & the use of Pertalite + Pertamax steam was heated with the same result of 2.04 ml/minute. In the 2500 rpm chart the lowest consumption is with the use of pertalite + pertamax steam of 3.32 ml/minute. In the 3500 rpm chart the lowest consumption was using pertalite + Pertamax steam heated at 3.92 ml/minute and on the 5000 rpm chart the lowest consumption was 4.36 ml/minute using pertalite + Pertamax steam. From the graph, it can be concluded that the average of various rpm, the use of heated pertalite + Pertamax steam achieved the lowest fuel consumption, which means that the use of heated Pertalite + Pertamax steam had a significant effect on fuel consumption.

B. Exhaust gas emissions

Exhaust gas data collection in this study is the levels of CO, CO2 and HC, and get the results in Table 3.

Table 3. Exhaust gas emissions

rpm	CO			CO_2			HC		
	Pertalite	Pertalite + Pertamax steam	Pertalite + Pertamax steam heated	Pertalite	Pertalite + Pertamax steam	Pertalite + Pertamax steam heated	Pertalite	Pertalite + Pertamax steam	Pertalite + Pertamax steam heated
	(%vol)	(%vol)	(%vol)	(%vol)	(%vol)	(%vol)	(ppm)	(ppm)	(ppm)
1500	1,92%	3,22%	0,95%	1,80%	1,10%	2,00%	682	3355	356
2500	2,88%	2,47%	3,38%	1,40%	1,10%	1,30%	1644	1603	1082
3500	4,00%	2,73%	2,52%	2,00%	1,20%	1,00%	956	959	1379
5000	3,01%	3,15%	3,19%	1,30%	1,40%	1,30%	1386	1660	1446

Looking at the test results in Table 3, we can analyze the engine performance conditions at certain engine speeds as follows :

1. *Idling stasioner* at 1500 rpm. At this speed the temperature in the combustion chamber is not high enough to vaporize the gasoline. This can cause unstable combustion. To prevent this, it is necessary to control the richness of the air-fuel mixture (improvement of the fuel supply section) so that complete combustion is not possible and the concentration of CO and HC in the exhaust gas increases.
2. Low and medium speed (2500 rpm to 3500 rpm). This condition is a lean/poor mix compared to the idle state. In this state, fully open the throttle valve. This increases the temperature in the combustion chamber and reduces CO and HC emissions.
3. High rpm (5000 RPM) This condition produces more power because the engine speed is higher, the mixture is richer, and CO and HC can increase due to lack of oxygen. In this case, it is necessary to adjust the intake air volume by adjusting the air inlet adjusting screw on the side of the carburetor.

From the three data points above, it can be seen that idle and medium conditions tend to produce higher emissions or incomplete combustion. On the other hand, in the low and medium rpm range, combustion is almost complete.

1. CO levels.

The results of CO exhaust gas research results with variations in the use of pertalite, pertalite + Pertamax steam & pertalite + heated Pertamax steam, can be seen in Figure 6.

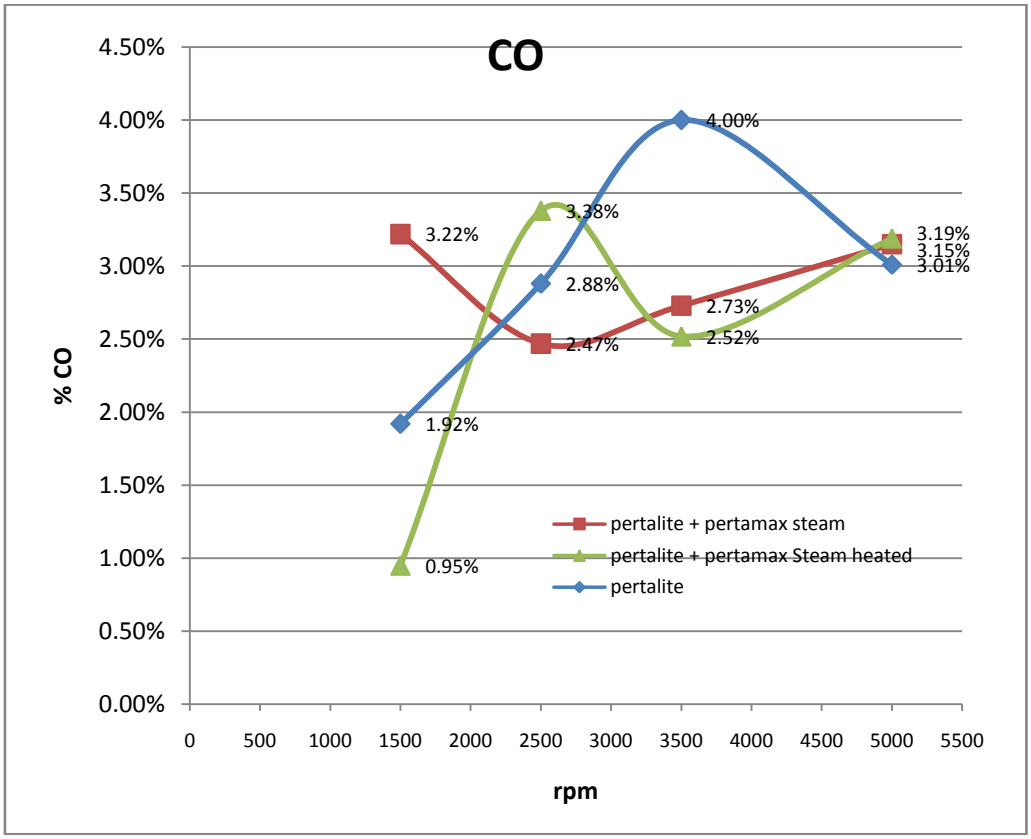

Figure 6. Graph of CO exhaust gas versus rpm

As the engine speed increases, it is known that CO levels show an unstable graph trend, meaning that there is an increase and decrease that is not constant. at 1500 rpm pertalite fuel is at 1.92%, pertalite + pertamax steam is highest at 3.22% and pertalite + Pertamax steam is heated the lowest at 0.95%. at 2500 rpm pertalite fuel rose at 2.88%, pertalite + pertamax steam dropped at 2.47% and pertalite + heated pertamax steam rose significantly by 3.38%. at 3500 rpm pertalite fuel significantly rose to the highest at 4.00%, pertalite + pertamax steam fell at 2.73% and pertalite + pertamax steam heated at 2.52%. at 5000 rpm pertalite fuel is at 3.01%, pertalite + pertamax steam is down at 3.15% and pertalite + pertamax steam is heated at 3.19%. So the lowest %CO is pertalite fuel + Pertamax steam heated at 1500 rpm at 0.95%, and the highest %CO is pertalite fuel at 3500 rpm at 4%.

2. CO_2 levels

The results of CO2 exhaust gas research results with variations in the use of pertalite, pertalite + pertamax steam & pertalite + heating Pertamax steam, can be seen in Figure 7.

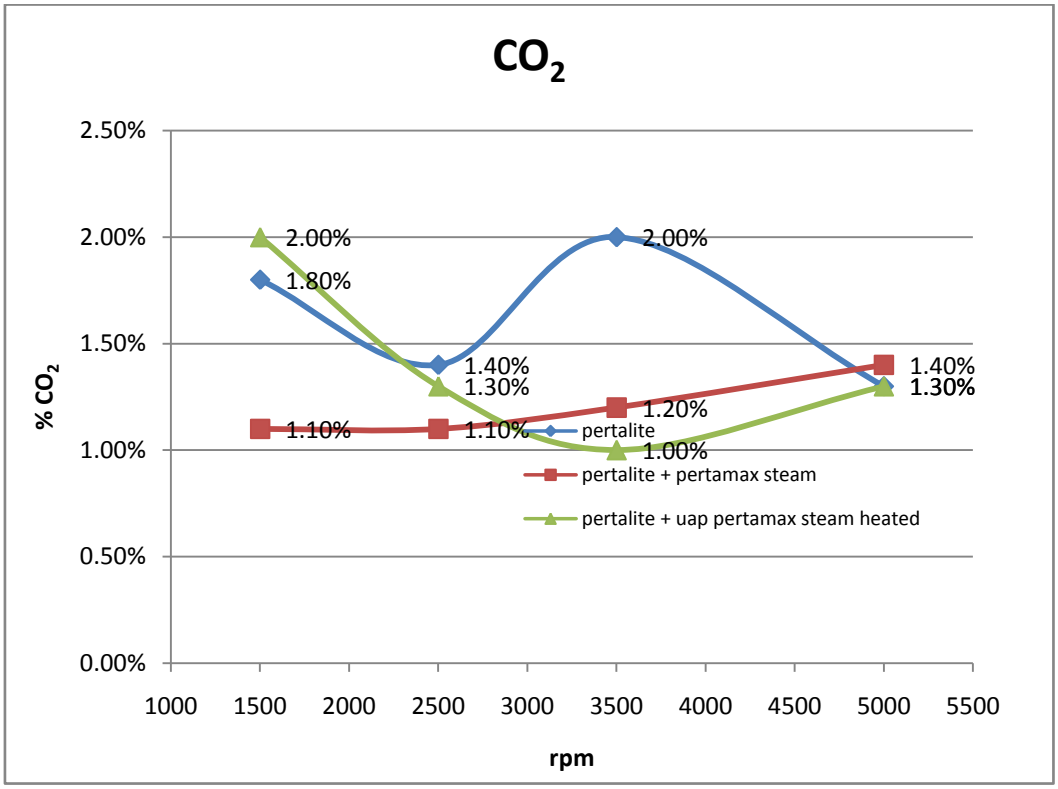

Figure 7. Graph of CO2 exhaust gas versus rpm

As the engine speed increases, it is known that CO2 levels show different graphic trends, at 1500 rpm pertalite fuel is at 1.8%, pertalite + Pertamax steam is 1.1% and Pertalite + Pertamax steam is heated the highest at 2%. at 2500 rpm pertalite fuel fell at 1.4%, pertalite + pertamax steam remained at 1.1% and pertalite + heated pertamax steam dropped to 1.3%. at 3500 rpm pertalite fuel rose the highest at 2%, pertalite + Pertamax steam at 1.2% and Pertalite + Pertamax steam heated the lowest at 1%. at 5000 rpm the fuel is pertalite at 1.3%, pertalite + Pertamax steam at 1.4% and pertalite + Pertamax steam is heated at 1.3%. so the lowest CO2 is pertalite fuel + pertamax steam heated by 1% at 3500 rpm and the highest CO2 is 2% in pertalite fuel at 3500 rpm and pertalite fuel + pertamax steam heated at 1500 rpm.

3. HC levels.

The results of HC exhaust gas from research with variations in the use of pertalite, pertalite + pertamax steam & pertalite + heating Pertamax steam, can be seen in Figure 8.

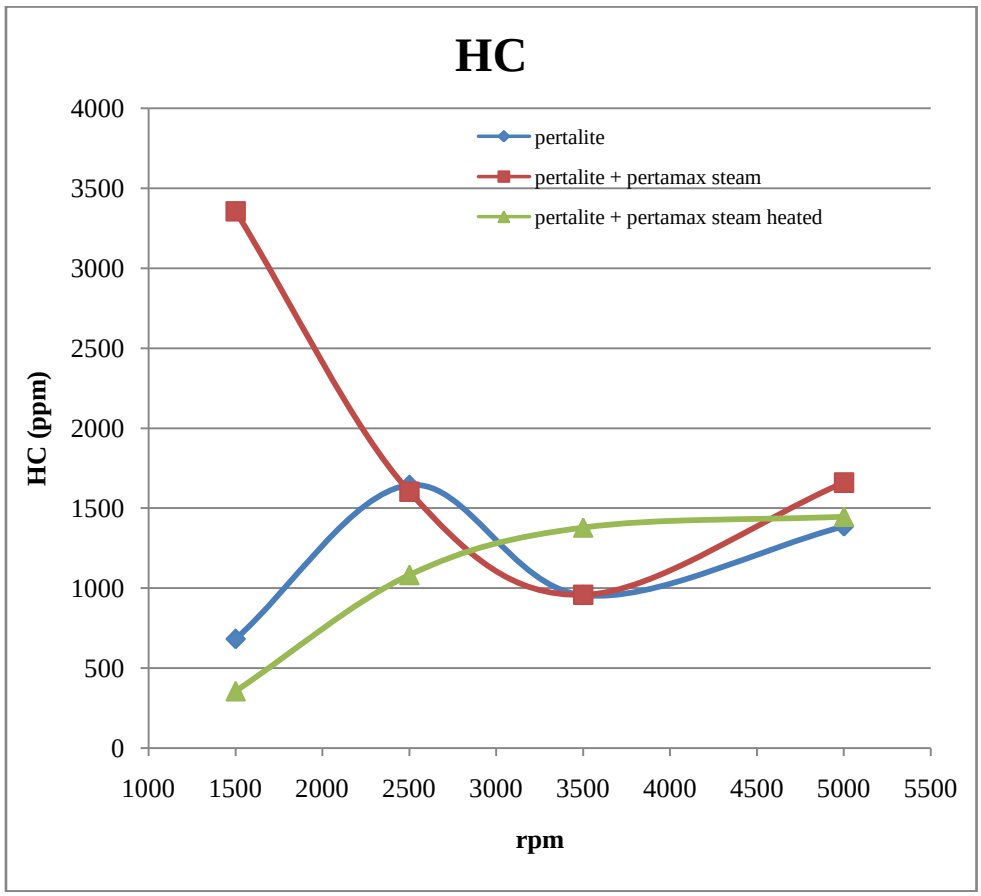

Figure 8. Graph of HC levels versus rpm

As the engine speed increases, it is known that the HC levels show different graphic trends, at 1500 rpm pertalite fuel at 682ppm, pertalite + Pertamax steam the highest at 3355ppm and Pertalite + Pertamax steam heated the lowest at 356ppm. at 2500 rpm pertalite fuel drops at 1603ppm, pertalite + pertamax steam rises at 1644ppm and pertalite + heated pertamax steam rises 1082ppm. at 3500 rpm pertalite fuel at 956ppm, almost the same as pertalite + Pertamax steam at 959ppm and Pertalite + Pertamax steam heated at 1379ppm. at 5000 rpm the fuel is pertalite at 1386ppm, pertalite + Pertamax steam at 1446ppm and Pertalite + Pertamax steam is heated at 1660ppm. so the lowest HC is pertalite fuel + pertamax steam heated at 356ppm and the highest HC is pertalite fuel at 3355ppm each at 1500 rpm.

IV. CONCLUSION

From this research, it can be concluded that the use of additives as additives to fuel in the form of Pertamax or heated steam has an effect on engine performance. The results showed that at 5000 rpm the highest consumption was with the use of pertalite at 9.82 ml/minute, the lowest consumption was in the use of pertalite + Pertamax steam heated at 4.36 ml/minute, there was a significant decrease in consumption of the use of additives. And it can be concluded that the average of various rpm, the use of heated pertalite + Pertamax steam achieved the lowest use of fuel consumption, which means that the use of heated Pertalite + Pertamax steam had a significant effect on fuel consumption. So it can be concluded that the use of additives as additives to fuel in the form of Pertamax or heated steam affects engine performance, namely a decrease in fuel consumption. The conclusion from the exhaust gas emissions, the lowest CO content is pertalite fuel + pertamax steam heated at 0.95% vol at 1500 rpm, and the highest CO content is pertalite fuel at 4% vol at 3500 rpm. Then the lowest CO2 content is pertalite fuel. + Pertamax steam is heated by 1% vol at 3500 rpm and the highest CO2 is 2% vol in pertalite fuel at 3500 rpm and 2% vol at pertalite fuel + Pertamax steam is heated at 1500 rpm. Meanwhile, the lowest HC content is pertalite fuel + Pertamax steam is heated at 356ppm and the highest HC content is pertalite fuel at 3355ppm at the same engine speed at 1500 rpm

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