Effect of Diameter Hole Size Main Jet on Performance and Emissions on the Use of Fuel Liquid Petroleum Gas (LPG)

Andika Bagus Nur Rahma Putra, Poppy Puspitasari
Department of Mechanical Engineering
Universitas Negeri Malang
Indonesia
andickabagus@gmail.com, poppy@um.ac.id

***Abstract*— In a modified carburetor systems often are changed only diameter main jet becomes larger than the standard size, regardless of the power and emissions produced. In general, the use of these vehicles uses fuel oil. Today the use of alternative fuels began to be used, one of the alternative fuels that substitute for petroleum that is LPG (Liquid Petroleum Gas). In this study used trial with throttle fixed with a varied round. Results from this research that there is a significant effect of the replacement of the size of the hole diameter of the main jet to power the motor on a motorcycle.**

Keywords—component; formatting; style; styling; insert (key words)

I. INTRODUCTION

In the process of burning the gasoline motor of four steps often occur some losses that caused the lack of complete combustion in the combustion chamber [1][5]. Fuel mixing with air caused engine performance to be down. The work done to improve the combustion process to minimize fuel is not burned (left) in the combustion process in the engine cylinder. In the gasoline motor, this can be done with set mixing process between the fuel with air before entering the combustion chamber to be more homo-geneous so that combustion can be better and the heat energy produced will increase [2][5].

In a modified carburetor system often are changed only diameter main jet becomes larger than the standard size [3][6], regardless of the power and the resulting emissions, but to increase the required mixing of air and fuel right. Enlarging the main jet is too big cause fuel will always excessive, resulting in incomplete combustion and fuel consumption is not economical. With incomplete combustion and fuel consumption uneconomical could cause exhaust emissions produced becomes large, so that the air pollution become increasingly high [4][7]. To suppress the higher levels of pollution, each vehicle owners need to test motor vehicle exhaust emissions [8]. The goal that the used vehicle meets the exhaust emission quality standards as prescribed

In general, the use of those vehicles using fuel oil which has negative effects that harm humans, are already many ways in which to minimize the impact, ranging from combustion systems to materials used fuels [9]. Today the alternative of fuels began to be used. One ingredient alternative fuels that substitute for petroleum that is LPG, which is where the LPG previously used for cooking now starting to be used for motor vehicles [10]. All development efforts in fuel utilization is continuously performed to obtain maximum results. One thing is becoming a reference in the development of the mixture of fuel gas and air in the carburetor. As has been known to LPG that is often used in the form of gas, so the use of a standard main jet factory defaults certain not suitable for use in this alternative, because the main jet designed for liquid fuel is gasoline [7]. However not too casually use the main jet of a certain size to get good performance with fuel LPG but also have to note the negative impact on the size of the main jet replacement is the result of exhaust emissions.

This study aimed to determine whether the replacement of the hole diameter main jet in the carburetor can affect motor power using fuel Liquid Petroleum Gas (LPG), determine whether the replacement of the size of the hole diameter main jet in the carburetor can affect exhaust emissions using fuel Liquid Petroleum Gas (LPG).

II. METHOD

The research method used in this study is a quasi-experimental research method, which was tested in a state machine is not budge. It is used to determine the effect of variations in the size of the hole diameter main jet on the performance and exhaust emissions of petrol 4 stroke that use LPG. In this study used trial with throttle fixed with a varied round. The independent variable is the large diameter main jet hole. Variable bound include effective power and exhaust emissions. Variable control: (1) the motor is at rounds in 2600, 3100, 3600; (2) the motor on the load test course and the 4th gear (gear ratio 4); (3) *dinotest*, to measure engine power; (4) gas analyzer, to measure the levels of exhaust emissions; (5)

The four Supra Fit motorcycles 4 stroke 100 cc; and (6) 3 kg LPG bottled issued by PT Pertamina.

Data collection techniques used in this study is to collect data that has been obtained from results of the experiment and loaded on the observation sheet. Data collection is done by observations on each of the main jet and the conditions of the particular round. Statistical analysis used in the study of two-way analysis of variance. Analysis of variance was used to determine whether or not the influence of the size of the hole diameter of the main jet and engine performance parameters that have been mentioned earlier. Due to the accuracy of the data to be retrieved at any particular large round repeated 3 times for data retrieval engine performance and exhaust emissions at any size main jet. Data analysis was performed with SPSS 16 for Windows with a significance level of 0.01.

An internal combustion engine with the following specifications:

Main jet is a test specimen in the carburetor, where this research using a variation of the hole diameter main jet. Diameter is 0.72; 1.02; 1.10.; 1.18. Auxiliary equipment used in this study are:

TABLE I. SPECIFICATIONS OF MOTORCYCLE

Specification	Description
Type of machine	4 stroke OHC , air conditioning
empty weight	99.4 kg
The capacity of the fuel tank	3.7 liter
diameter steps	50 x 49.5 mm
Volume measures	97.1 cm³
the compression ratio	8.8 : 1
maximum power	0.74 Kgf. M / 6000 rpm
Maximum torque	7.29 PS / 7000 rpm
system starter	kick starter and electric starter
clutch	automatic centrifugal , wet type , double type
transmission gear	4 speed with rotary system
battery	12 V-5 Ah
plugs	ND U-22FS-U/NGK HAS C7
ignition System	CDI-conditioned,magneto (Capactive Discharge Ignition)

TABLE II. TOOL SUPPORT

Tool's Name	Function
Measuring cup	measuring the consumption of fuel used during the test
tachometer	measure the rotation speed of the engine shaft
Automotive Emission Analyzer	measuring the torque / motor power
blower	cool the engine.
Toolbox	-
dynamometer	measuring the levels of exhaust emissions.

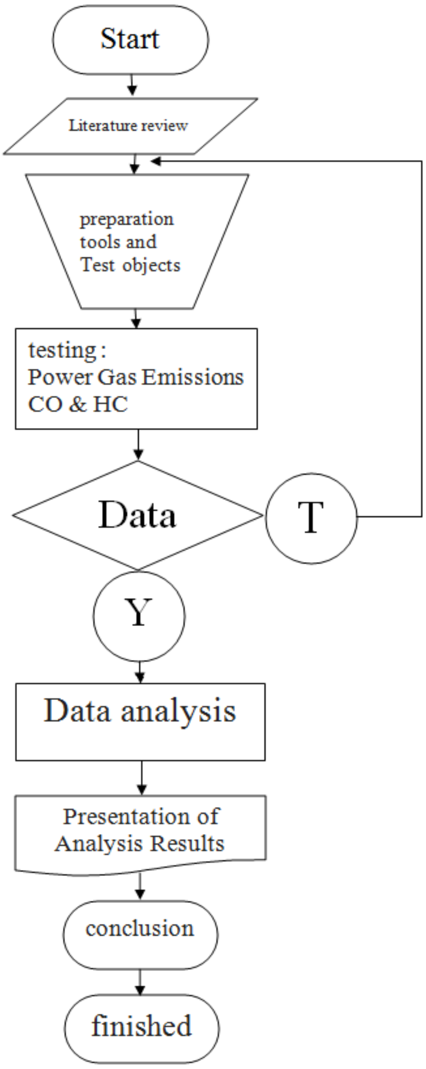

Fig. 1. flowchart research

In this study described the steps in flowchart form as follows:

Testing steps include:

- 1. Preparing the observation sheet and test equipment settings
- 2. Engine start is turned on and leave it on for approximately ± 15 minutes with the intention that reach engine working conditions then the engine switched off
- 3. After cooling and setting the test equipment ± 20 minutes, the machine is turned on again. Then do the data collection, where the testing using the main jet with a hole diameter of 0.72 mm. Data collection is

done by using a rotation 2600 rpm, 3100 rpm and 3600 rpm. To obtain more accurate data to be repeated three times for each round.

- 4. Next to the carburetor, the main jet is replaced with a hole diameter of 1.02. 1.10. and 1,18.sedangkan process of testing and data collection together with the number 3.
- 5. For data retrieval about exhaust emission levels do three repetitions at a time for 20 seconds of each round of 2600, 3100, 3600
- 6. recording the results with power and exhaust emission levels produced.

III. Results

Data power and exhaust emission levels taken from the results of experiments on *Supra Fit 100 cc* motorcycle which uses variations in the size of the hole diameter main jet in a particular round the same treatment done 3 times.

A. Effect of Variation of the average Rpm Power (HP)

Based on the analysis of the two lines above it can be concluded that all three had an average of data that differ significantly because of the Sig. (0,000)<0.01. Average-average engine power with Rpm variation is significantly different.

TABLE III. Subjects Test With Variable Power

Source	F	Sig.
Corrected Model	26.537	.000
Intercept	3.976E4	.000
Rpm	80.286	.000
Diameter	31.183	.000
Rpm * Diameter	6.297	.000
Error		
Total		
Corrected Total		

TABLE IV. Host Test Post Bound With Variable Power Variations Based On Rpm

(I) Rpm	(J) Rpm	Mean Difference (I-J)	Sig.
2600	3100	-.5825*	.000
	3600	-1.2925*	.000
3100	2600	.5825*	.000
	3600	-.7100*	.000
3600	2600	1.2925*	.000
	3100	.7100*	.000

TABLE V. Post Hoc Test With Variable Power Bound By Hole Diameter Variation Main Jet

(I) Diameter	(J) Diameter	Mean Difference (I-J)	Sig.
0.72	1.02	-1.0089*	.000
	1.10	-.6933*	.000
	1.18	-.9644*	.000
1.02	0.72	1.0089*	.000
	1.10	.3156	.060
	1.18	.0444	.981
110	0.72	.6933*	.000
	1.02	-.3156	.060
	1.18	-.2711	.127
1.18	0.72	.9644*	.000
	1.02	-.0444	.981
	1.10	.2711	.127

B. The difference in average power (HP) By Variations Rpm

The average difference in power between 2600 rpm to 3100 rpm differ significantly because of the indigo Sig. (0,000) < 0.01 and 0.5825 HP magnitude difference. The average difference in power between 2600 rpm to 3600 rpm differ significantly Sig. (0,000) < 0.01 and 1.2925 HP magnitude difference. The average difference in power between 3100 rpm to 3600 rpm differ significantly because of the indigo Sig. (0,000) < 0.01 and 0.7100 HP magnitude difference.

C. The difference in average power (HP) Based on Main Jet Hole Diameter Variation

The difference in average power (HP) based on variations in the diameter of the main jet hole can be seen in table

The average difference in power between the main jet orifice diameter of 0.72 mm to 1.02 mm differ significantly because of the Sig. (0,000) < 0.01 and 1.0089 HP magnitude difference. The average difference in power between the main jet orifice diameter of 0.72 mm to 1.10 mm differ significantly because of the Sig. (0,000) < 0.01 and 0.6933 HP magnitude difference. The average difference in power between the main jet orifice diameter of 0.72 mm to 1.18 mm differ significantly because of the Sig. (0,000) < 0.01 and 0.9644 HP magnitude difference. The average difference in power between the main jet orifice diameter of 1.02 mm to 1.18 mm did not differ significantly because of the Sig. (0,981) > 0.01 and the magnitude of the HP 0.0444.

D. Effect of Variation Rpm against average CO (% volume)

Rpm variation influence on the average CO (% volume) can be seen on the Test of Between- Subjects Effects, part RPM.

TABLE VI. SUBJECTS BETWEEN- EFFECTS OF TEST WITH VARIABLE BOUND CO

Source	Type III Sum of Squares	F	Sig.
Corrected Model	9.680[a]	1.304E3	.000
Intercept	4.980	7.378E3	.000
Rpm	2.475	1.833E3	.000
Diameter	2.540	1.255E3	.000
Rpm * Diameter	4.665	1.152E3	.000
Error	.016		
Total	14.676		
Corrected Total	9.696		

TABLE VII. POST HOC TEST WITH VARIABLE BOUND CO (% VOLUME) VARIATIONS BASED ON RPM

(I) Rpm	(J) Rpm	Std. Error	Sig.
2600	3100	.01061	.000
	3600	.01061	.000
3100	2600	.01061	.000
	3600	.01061	.000
3600	2600	.01061	.000
	3100	.01061	.000

Based on the analysis of the two lines above it can be concluded that all three had an average of data that differ significantly because of the Sig. (0,000) < 0.01. Average-average CO (% volume) with Rpm variation is significantly different. Average CO (% volume) engine with 2600 rpm (0.7358 %) is higher than the engine at 3100 rpm (0.2517 %), higher than the engine with 3600 rpm (0.1283 %).

E. The difference in average CO (% volume) By Variations Rpm

The difference in average CO (% volume) based on Rpm variations can be seen in Table VII.

The difference in average CO (% volume) between 2600 rpm to 3100 rpm is significantly different because the Sig. (0,000) < 0.01 and magnitude of the 0.4842 %. The difference in average CO (% volume) between 2600 rpm to 3600 rpm is significantly different because the Sig. (0,000) < 0.01 and magnitude of the 0.6075 %. The difference in average CO (% volume) between 3100 rpm to 3600 rpm is significantly different because the Sig. (0,000) < 0.01 and magnitude of the 0.1233 %.

TABLE VIII. POST HOC TEST WITH VARIABLE BOUND CO (% VOLUME) HOLE DIAMETER VARIATIONS BASED ON MAIN JET

(I) Diameter	(J) Diameter	Std. Error	Sig.
0.72	1.02	.01225	.000
	1.10	.01225	.000
	1.18	.01225	.000
1.02	0.72	.01225	.000
	1.10	.01225	.000
	1.18	.01225	.000
1.10	0.72	.01225	.000
	1.02	.01225	.000
	1.18	.01225	.000
1.18	0.72	.01225	.000
	1.02	.01225	.000
	1.10	.01225	.000

F. The difference in CO (% volume) Based on Main Jet Hole Diameter Variation

Differences CO (% volume) based on variations in hole diameter Main Jet can be seen in Table VIII.

The difference in average CO (% volume) between the size of the main jet orifice diameter of 0.72 mm to 1.02 mm differ significantly because of the Sig. (0,000) < 0.01 and magnitude of the 0.3456 %. The difference in average CO (% volume) between the size of the main jet orifice diameter of 0.72 mm to 1.10 mm differ significantly because of the Sig. (0,000) < 0.01 and magnitude of the 0.5344 %. The difference in average CO (% volume) between the size of the main jet orifice diameter of 0.72 mm to 1.18 mm differ significantly because of the Sig. (0,000) < 0.01 and magnitude of the 0.1422 %.

The difference in average CO (% volume) between the size of the main jet orifice diameter of 1.02 mm to 1.18 mm differ significantly because of the Sig. (0,000) < 0.01 and magnitude of the 0.4878 %.

G. The difference in average HC (ppm) Based on Variation Rpm

The average difference HC (ppm) based on Rpm variations can be seen in Table IX.

The average difference HC (ppm) between 2600 rpm to 3100 rpm is significantly different because the Sig. (0,000) < 0.01 and the magnitude of the difference 236.2500 ppm. The average difference HC (ppm) between 2600 rpm to 3600 rpm is significantly different because the Sig. (0,000) < 0.01 and the magnitude of the difference 180.0833 ppm. The average difference HC (ppm) between 3100 rpm to 3600 rpm is significantly different because the Sig. (0,000) < 0.01 and the magnitude of the difference 416.3333 ppm.

TABLE IX. POST HOC BOUND WITH VARIABLE HC (PPM) BASED ON VARIATION

(I) Rpm	(J) Rpm	Mean Difference (I-J)	Std. Error	Sig.
2600	3100	-236.2500*	15.45528	.000
	3600	180.0833*	15.45528	.000
3100	2600	236.2500*	15.45528	.000
	3600	416.3333*	15.45528	.000
3600	2600	-180.0833*	15.45528	.000
	3100	-416.3333*	15.45528	.000

TABLE X. POST HOC BOUND WITH VARIABLE HC (PPM) HOLE DIAMETER VARIATIONS BASED ON MAIN JET

(I) Diameter	(J) Diameter	Mean Difference (I-J)	Std. Error	Sig.
0.72	1.02	818.7778*	17.84622	.000
	1.10	834.4444*	17.84622	.000
	1.18	884.7778*	17.84622	.000
1.02	0.72	-818.7778*	17.84622	.000
	1.10	15.6667	17.84622	.816
	1.18	66.0000*	17.84622	.006
1.10	0.72	-834.4444*	17.84622	.000
	1.02	-15.6667	17.84622	.816
	1.18	50.3333	17.84622	.044
1.18	0.72	-884.7778*	17.84622	.000
	1.02	-66.0000*	17.84622	.006
	1.10	-50.3333	17.84622	.044

H. *The difference in average HC (ppm) Based on Main Jet Hole Diameter Variation*

Differences HC (ppm) based on variations in the diameter of the main jet hole can be seen in Table X.

The average difference HC (ppm) between the size of the main jet orifice diameter of 0.72 mm to 1.02 mm was significantly different because the Sig. (0,000) <0.01 and the magnitude of the difference 818.7778 ppm. The average difference HC (ppm) between the size of the main jet orifice diameter of 0.72 mm to 1.10 mm was significantly different because the Sig. (0,000) <0.01 and the magnitude of the difference 834.4444 ppm. The average difference HC (ppm) between the size of the main jet orifice diameter of 0.72 mm to 1.18 mm was significantly different because the Sig. (0,000) <0.01 and the magnitude of the difference 884.7778 ppm. The average difference HC (ppm) between the size of the main jet orifice diameter of 1.02 mm to 1.18 mm was significantly different because the Sig. (0.006) <0.01 and the magnitude of the difference 66.0000 ppm.

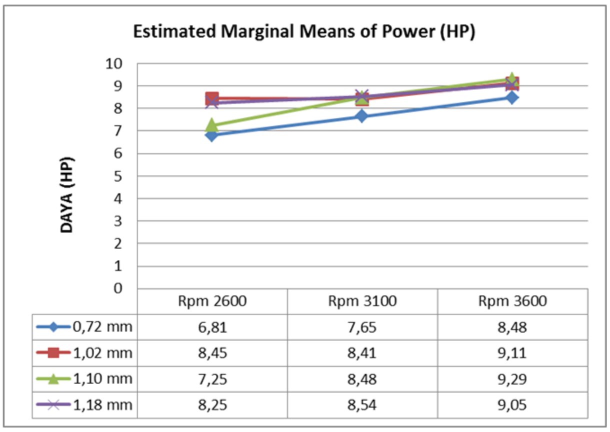

Fig. 2. Diameter Hole Size chart Variations of the Main Jet Power

IV. DISCUSSION

This discussion includes three things: the influence of the hole diameter of the main jet to the power generated. The hole diameter main jet influences on levels of CO produced, and the effect of hole diameter main jet against HC generated content. This discussion includes three things: the influence of the hole diameter of the main jet to the power generated, the hole diameter main jet influences on levels of CO produced, and the effect of hole diameter main jet against HC generated content.

A. *Effect of Hole Diameter Main Jet for Generated Power*

Based on statistical analysis of the data with the help of a computer program SPSS data presentation summary of the model shown in Fig.2.

With the F-test was used to test the significance of the relationship between the independent variable and dependent variable.

Based on testing, Ho accepted if more probability greater than 0.01 and Ho is rejected if the probability is less than 0.01. The second that the data had average differed significantly with an average engine power with engine size variation is the main jet orifice diameter that is significantly different.

Can be seen in Fig.2 as a whole based on the calculation of average power Supra Fit 100 cc motorcycle which uses the size of the main jet orifice diameter of 1.02 mm has a power of 8.45 HP at 2600 rpm, is greater than the diameter of the hole using the size 0, 72 mm, 1.10 mm and 1.18 mm. For medium rotation is 3100 rpm peak power contained in the main jet 1.18 mm with 8.54 HP power, and for high speed power usage is highest at the main jet 1,1 mm with 9.29 HP power.

The above results are caused because the research is not done adjusting the settings on each test condition but uses standard air setting is the size of the diameter of 0.72 mm by 1.5 rounds left after playing stuck to the right. By setting this standard, if the main jet to be replaced with a smaller size caused mix too poor where fuel is less than the incoming air so that the generated power down. In the main jet orifice diameter of 1.18 mm less than the maximum power generated, it is because the air settings standard fuel coming too much, causing the mixture is too rich. Based on the graphic power performance (at constant rpm) which was discussed showing that the poor mix of fuel and air, the generated power is getting down [8][10]. The same thing happens when the richer mixture of fuel and air, the power generated to be down as well. Because the mixture is rich, a lot of unburned fuel and ultimately wasted.

According Anshu states that "When carrying out the replacement of a larger main jet will affect the engine performance ranging from half throttle up to full gas (full throttle) [9]. Always do the replacement of one-by-one and gradually and look at the changes in engine performance before changing other factors "

So the size of the main jet hole diameter affect the power generated.

B. *Effect of Hole Diameter Main Jet against CO Generated Content*

Based on statistical analysis of data using SPSS rocks presentation of data in summary the model shown in Fig.3

With the F-test was used to test the significance of the relationship between the independent variable and the dependent variable. Based on testing, Ho accepted if the probability is greater than 0.01 and Ho is rejected if the probability is less than 0.01. The second that the data had average differed significantly at an average level of CO to the size of the main jet orifice diameter of 1.10 mm (0.7144%), higher than a machine with a main jet orifice diameter of 1.02 mm (0, 5356%), higher than the machine with a main jet orifice diameter of 0.72 mm (0.1900%), higher than the machine with a main jet orifice diameter of 1.18 mm (0.0478%).

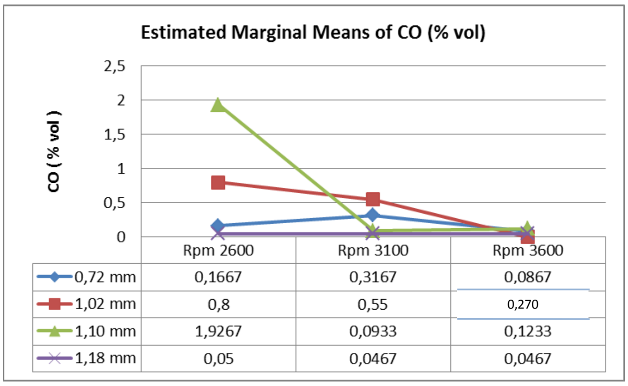

Fig. 3. Variation chart Size Hole Diameter Main Jet against CO (% volume)

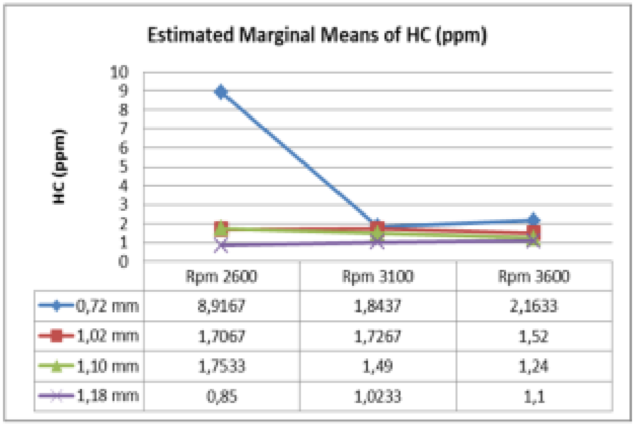

Fig. 4. Variation chart Size Hole Diameter Main Jet against HC (ppm)

In addition to the size of the holes diameter main jet, the engine rotation also affect the CO produced [5]. The larger the engine rotations, the smaller levels of CO are produced because fuel mixture becomes increasingly thinner. When the engine and gasoline increased spraying in the nozzle, then the amount of air flow into the tube emulation on gasoline. With the formation of emulation in the gas channel between the main jet and nozzle means fuel mixture will be poor, the comparison mix at different speed levels as required in the cylinder chamber, combustion occurs more perfect. The required oxygen in the combustion fulfilled so as to minimize the levels of CO resulting from [7].

So the size of the hole diameter main jet effect on the levels of CO produced.

C. *Effect of Hole Diameter Main Jet against HC Generated Content*

Based on statistical analysis of data using SPSS computer program aid program presenting summary data on the model shown in Fig.4.

With the F-test was used to test the significance of the relationship between the independent variable and the dependent variable. The second that the data had average differed significantly at an average level of HC to the size of the main jet orifice diameter of 0.72 mm (9.8389 ppm) is higher than the engine with the main jet hole diameter of 1.02 mm (1.6511 ppm), which is higher than the engine with the main jet hole diameter of 1.10 mm (1.4944 ppm), which is higher than the engine with the main jet hole diameter of 1.18 mm (0.9900 ppm).

In this study, the levels of HC were out getting lower with increasing size of the holes diameter main jet. This is caused by the increasingly poor mix of replacement main jet orifice diameter so that the fuel burned in its entirety.

In addition to the size of the holes diameter main jet, the engine rotation also affect the levels of HC produced [6]. When the engine rotation increases, the amount of air flow of outside air will get into the tube to create the emulsion on LPG, so spraying nozzle not only on LPG alone but a mixture of fuel and air. With LPG in the formation of emulsions in the channel between the main jet and nozzle means fuel mixture will be poor [10]. The comparison mix at various levels in accordance with the necessary speed in the cylinder, more complete combustion, LPG is not wasted in vain. The cause of hydrocarbon emissions is fuel that is not perfect so out into the raw gas and fuel are divided over high heat reaction became HC cluster other out with the exhaust gases [7]. By creating this emulsion will certainly lead to more complete combustion and in accordance with different levels of speed required in combustion occurs in the cylinder chamber so will minimize HC generated content.

So the size of the hole diameter main jet having an effect on levels of HC produced.

V. Conclusion

Based on the research that has been done at low speed of rpm used the best results on the size of the main jet diameter of 1.02 mm (8.45 HP) with emissions of CO (0.8%) and HC (170 ppm) for high speed contained in main jet 1,10 mm (9.29 HP) with emissions of CO (0.3%) and HC (124 ppm), it can describe things as follows:

First, there was a significant effect of the replacement of the size of the hole diameter of the main jet motor power on Supra Fit motorcycles of 100 cc. *Secondly*, the average engine power to the main jet hole diameter of 1.10 mm at 3600 rpm (9.2933 HP) is higher than the engine with the main jet hole diameter of 1.02 mm at 3600 rpm (9.1100 HP), higher of the machine with a main jet orifice diameter of 1.18 mm at 3600 rpm (9.0500 HP), is higher than the engine with the main jet orifice diameter of 0.72 mm at 3600 rpm (8.4833 HP). *Third*, there is a significant effect of the replacement of the size of the hole diameter of the main jet exhaust emissions on Supra Fit motorcycles of 100 cc. *Fourth*, the average levels of CO (% volume) machine with a main jet orifice diameter of 1.02 mm at 3600 rpm (0.2567%) is higher than the engine with the main jet hole diameter of 1.10 mm (0.1233%), higher than on a machine with a main jet diameter of 0.72 mm (0.0867%). More height of the main jet engine with a diameter of 1.18 mm (0.0467%). *Fifth*, the average HC concentration (ppm) engine with a bore diameter of 0.72 mm main jet at 3600 rpm (2.1633 ppm) is higher than the engine with the main jet hole diameter of 1.02 mm at 3600 rpm (1.5200 ppm), is higher than the engine with the main jet hole diameter of 1.10 mm at 3600 rpm (1.2400 ppm), which is higher than the engine with the main jet hole diameter of 1.18 mm at 3600 rpm (1.1000 ppm).

References

[1] Bottiglione, Francesco. Energy Consumption of a Battery Electric Vehicle with Infinitely Variable Transmission. Energies Journal, 7th ed, vol. 1. 2014. pp. 317-337.

[2] Gangwar, G., K.. Study Of Closed -Circuit Hydraulic Energy Regenerative System For Hydrostatic Transmission Drive Using Hy-draulic Accumulator. International Journal Of Research In Aeronautical And Mechanical Engineering, 1st ed, vol.2. 2014. pp.1-10.

[3] Makwan, and Romesh. Analysis of Auto-Gear Shifting Mechanism on different Load Conditions. International Journal Of Engineering Sciences & Research Techno-logy, 8th ed, vol.3. 2014. pp. 737-739.

[4] S. Mahadeokar, and A. Choudhary, A Review On “Finite Element Analysis Of Chassis Using Ansys”. International Journal Of Research In Aeronautical And Mechanical Engineering, 10th ed, vol.3. 2014. pp.16-21.

[5] Z. Salhab, M. G. Qawasmi, and H. Amro, Comparative Performance and Emission Properties of Spark-Ignition Outboard Engine Powered by Gasoline and LPG. Jordan Journal of Mechanical and Industrial Engineering, 1st ed, vol.5, India, 2011, pp. 47 – 52.

[6] N. A Siddiquia, A. Ramakrishnab, and P. S. Lalc, Review On Liquefied Petroleum Gas Cylinder Acceptance Test As Per Indian Standard, International Journal of Advanced Engineering Technology, 2nd ed, vol.4, India, 2013, pp.119-123.

[7] Yousufuddin, Performance and Emission Characteristics of LPG-Fuelled Variable Compression Ratio SI Engine, Turkish J. Eng. Env. Sci. 32th ed, Turkey, 2008, pp.7 – 12.

[8] A. S. Lanje1, and Prof. M. J. Deshmukh, Performance and Emission Characteristics of SI Engine using LPG-Ethanol Blends: A Review, International Journal of Emerging Technology and Advanced Engineering. 10th ed,vol. 2, India, 2012, pp.146-152

[9] M. Arafah, and M. I. Ramli, The Motorcycle Emission Charac-teristics in Developing Countries: Logit and Regression Analysis of I/M Data in Makassar City, Indonesia, Proceedings of the Eastern Asia Society for Transportation Studies, vol.9, Indonesia, 2013, pp.122-131.

[10] A. Srivastava, S. Srivastava, and A.C. Nigam, Alternative Fuel for Trans-portation, International Journal Of Envi-ronmental Sciences, 2nd, vol 1, India, 2010, pp.191-197.