Journal of Applied Science and Innovation Technology (ASAIT)
http://aiua.usas.edu.my/journal/ *Volume 2, Issue 2 (2020)*

PERFORMANCE STUDY ON THE EFFECT OF DIFFERENT EXHAUST LENGTH FOR MOTORCYCLE ENGINE USING GT POWER SOFTWARE

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ABSTRACT*: This research provides an overview of the performance on the effect of the different exhaust length for motorcycle engine. The research also covers the effect in terms of emissions. The engine used was a motorcycle 125cc 4-stroke gasoline engine. The engine specifications and measured components of exhaust system were used for modelling and visualization using GT-Power simulation software. The different length of exhaust will be used for the simulation. Brake power, brake mean effective pressure (BMEP) and brake specific fuel consumption (BSFC) of the engine are discussed as the performance of the engine. Besides that, carbon dioxide (CO2), carbon monoxide and hydrocarbon (HC) was discussed as the emissions of the engine. The performance test was conducted to investigate the different lengths of exhaust manifold will affect the engine performance and exhaust-out emissions.*

KEYWORDS - *Performance, Motorcycle engine, Exhaust length, GT Power software.*

I. INTRODUCTION

Exhaust system is a part of vehicle components. Nowadays, there are a few types of exhaust system that already developed to provide a specific user's demand. Mohiuddin, Rahamn, & Dzaidin, (2007) stated, the exhaust. According to Mohiuddin et al., (2007), a well-designed exhaust system is one of the cheapest ways of increasing engine efficiency, and therefore increasing engine power. The exhaust system is one of the components in the vehicle. The exhaust stroke is a system that works to remove the product of combustion from the internal combustion engine. Combustion residues through the exhaust valves and out into the environment. When the exhaust pressure occurs during the reversal of the exhaust process, it's disrupted the level of efficiency of the engine. Therefore, the size (length) of the exhaust is very important in ensuring the level of efficiency of the engine can achieve the maximum level. The study is to provide a new information on the impact of size (length) of exhaust manifold for motorcycle engine with the engine capacity of 125cc. Exhaust size is important to improve the efficiency of the engine of the vehicle.

At present, there are many different types of exhaust have been produced. This is to meet the needs of the production exhaust design that can improve the efficiency of the engine as well as the manufacturing cost. Mohiuddin, Rahamn, & Dzaidin (2007) explained, a well-designed exhaust system is one of the cheapest ways of increasing engine efficiency, and therefore increasing engine power. Patil, Navale, & Patil (2014) stated that energy efficient exhaust system development requires minimum fuel consumption and maximum utilization of exhaust energy for reduction of the exhaust emissions and also for effective waste energy recovery system such as in turbocharger, heat pipe etc. from combustion engine system. Mamat, Fouzi, Sulaiman, & Alias (2010) stated that optimum engine cylinder charging was achieved by breathing of an engine dependent on the design of intake and exhaust system.

This study focus on performance of motorcycle engine when the length of exhaust modified. According to Obodeh & Ogbor (2009) studied, engine performance is strongly dependent on gas dynamic phenomena in intake and exhaust systems. Han-chi, Hong-wu, & Yi-jie (2012) explained, performance of engine can be studied by analyzing the mass and energy flows between individual engine components and the heat and work transfers within each component.

To get better result for analysis exhaust, different condition of engine operates must be consider. From different condition the exhaust system can be develop with maximum utilization of available energy at the exhaust. Patil et al. (2014) stated, design of each device should offer minimum pressure across the device, so that it should not adversely affect the engine performance.

GT Power is industry-standard engine simulation tools, used by all leading engine and vehicle manufacturers and their suppliers. According to F1, NASCAR, IRL, etc all, is also used for ship and power generation's engines, small two and four stroke engines and racing engines. GT Power provide for the user with various of components to model any advanced concept. Faisal et al. (2010) studied; GT-Power is a program that widely used in an automotive research area. From the GT Power user manual, among its advantages is its ease of use and its tight integration with the rest of GT SUITE, which give GT Power a virtual engine perspective.

To develop the GT Power model, all components from selected engine need to be assemble part by part. The engine specifications will be used for modelling and visualization using GT-Power simulation software. Han-chi et al. (2012) has simplified their exhaust system by modelled it as a straight pipe and did not consider the effect of silencer. Also, the pressure losses in the ports are included in the discharge coefficients for the valves. Mohiuddin et al. (2007) explained, modelling is started from pipe parts of air induction process. Many assumptions and simplifications were made to the system in order to complete the model. Then, data will be recorded for analysis and discussion.

II. HEADING S/METHODOLOGY

The selected engine for this study is a motorcycle engine with engine capacity of 125cc. Table 1 shows the engine specification of 125cc four stroke motorcycle gasoline engine. Based on Mohd Faisal, Ahmad Jais, Hazlina, & Mohd Taufiq, (2013) research, four stroke spark ignition engine has been selected and are of interest because of they have the potential for very lean operation and they might operate unthrottled (or less throttled) at part load. Mohiuddin, Rahamn, & Dzaidin, (2007) stated, the major area of concern in the work is to focus on the engine of exhaust manifold instead of the whole components of exhaust system.

By using GT-Power software, the whole components of exhaust manifold must be considered to insert the parameters in the software for simulation and analysis because the exhaust manifold cannot perform by itself. The simulation and analysis process must have combination of all exhaust components. The components of exhaust system that will be measured are; exhaust manifold, catalytic converter, pipes, and muffler. The exhaust size for 125cc motorcycle engine take from the intake manifold to the end of pipe. Table 2 shows the different length of exhaust.

Table 1: The specification of 125cc four Stroke Motorcycle Gasoline engine

JUSTIFICATION	SPECIFICATION
Engine type	4 Stroke, SOHC, 2-valve
Cylinder	Single cylinder
Combustion system	Spark plug
Transmission	4 gear
Speed	125 cc
Piston	52 mm
Stroke	57.94 mm
Connecting rod	130 mm
Compression ratio	9.3:1
Maximum power	6.7 kW/7500 rpm
Maximum torque	1.05 kgf.m/5000 rpm
Top dead Centre	2

Bore	51.79 mm

Table 2: The different length of Exhaust

JUSTIFICATION	LENGTH
Standard exhaust length	106 cm
Long exhaust length	129.75cm
Short exhaust length	73.3cm

Before starting simulation, GT-Suite software uploaded into the computer. Then GT-Power selected to produce the model GT. GT-power was chosen because they fit the motor engine using internal combustion system. To produce the GT model, there are two parts that need to be known, namely: -

i. GT-Power
The selection of the components used in an engine and also the parameters available on the engine.
ii. GT-Post
GT-Post function to view and manipulate the data gathered while running simulation using GT-Power.

For the production process simulation using software GT-Power, there are a few procedures that need to be done to ensure the success of this simulation shown below:

i. Components should be constructed first.
ii. Then connect all the components have been built from the environment fill to the exhaust to form a model environment.
iii. Parameters for input components are set to include the reading of the parameters.
iv. The speed of the engine be determined from 500 rpm up to 10,000 rpm.
v. Before data is sent to the GT-Post, simulation needs to be done in advance by pressing the Run Simulation icon. Then, wait until the simulation finishes.
vi. Once the simulation successfully, the data to be manipulated and will be sent to the GT-Post to get results for engine performance.
vii. The results obtained not only in the form of graphs, but simulated results can also be displayed through a table.

III. INDENTATIONS AND EQUATIONS

The simulation investigation was using the GT-Power software. Simulation process involves three types of different exhaust lengths. Simulation was performed at engine speed ranging from 500 to 10,000 RPM. There are three results regarding the performance of the engine. The performance results of the test engine are Brake Power (BP), Brake Mean Effective Pressure (BMEP) and Brake Specific Fuel Consumption (BSFC). The results of this simulation process allow the study on the impact of difference exhaust length to the performance of engine and it can be used to determine the optimal length that producing better performance.

IV. FIGURES AND TABLES/DISCUSSION

Figure 1 shows the Brake Power generated by three types of exhaust length 500 to 10,000 RPM. Based on the figure, BP increases continuously from low to high engine speed. The highest BP as produced by long exhaust pipe which is around 11.1246 kW at engine speed of 10,000 RPM. While the lowest BP was produced by the standard exhaust pipe around 10.7071 kW.

Based on the figure, all types of exhaust length achieved their highest BP when the engine speed reached to the maximum. According to Gitano (2007), in his report – Dynamometer Basic, BP increases with the increasing of engine speed and the highest Brake Power will be produced at the highest speed. Similar result was presented by Mohd Faisal, Ahmad Jais, Hazlina, & Mohd Taufiq (2013), where they found that, increase in the engine speed will increase the BP. The same finding also been reported by Bagri & Chaube (2013). They found that at three different speeds (300, 500 and 700 RPM), BP increased as engine speed increased. The different in exhaust length will affect the BP. As can be seen in the figure, there is around 1.91% percentage different observed between the highest and lowest BP produced.

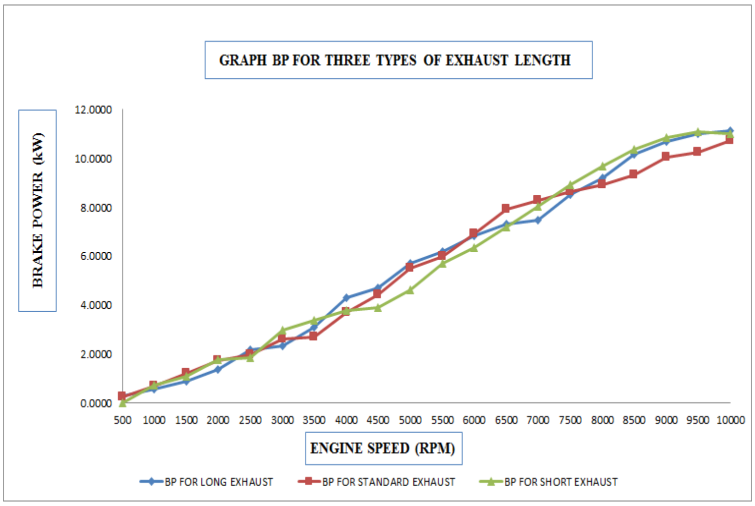

Figure 1: The result for Brake Power in simulation

Figure 2 shows BMEP for three types of exhaust length. Based on the figure, BMEP for long and short exhausts increases as engine speed increases from 500 to 8500 RPM and decreases as engine speed continue to increase until 10000 RPM. BMEP for standard exhaust pipe achieved the highest point at 6500 RPM and decline after that. It can be seen that, lower BMEP was produced by all types at lower engine speed. The highest BMEP value was occurred in the medium engine speed and starts to decrease as engine speed increase. The obtained result shows an agreement to the study that has been done by Mohd Faisal, Ahmad Jais, Hazlina, & Mohd Taufiq (2013). The same result also obtained by Schmick (2011) and Obodeh & Ogbor (2009) which is the highest level of BMEP was occurred in the range of the medium engine speed.

The highest BMEP which is approaching 12 Bar was produced by short exhaust pipe at 8500 RPM. High BMEP will produce high power per in-cylinder pressure. From the figure, there is around 1.04% percentage different between the highest and the lowest values of produced BMEP.

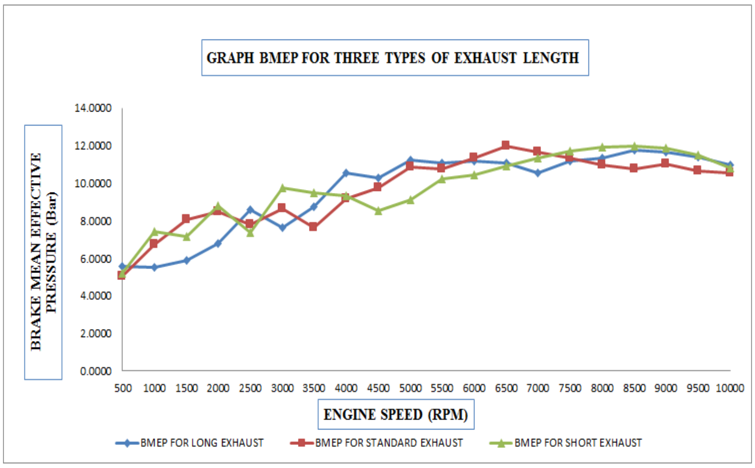

Figure 2: The result Brake Mean Effective Pressure in simulation

Figure 3 shows the Brake Specific Fuel Consumption (BSFC) for three types of different exhaust length. Long exhaust pipe consumes more fuel at 2000 RPM that resulting significant increase at this engine speed. The same pattern was also observed for standard exhaust at 2500 RPM. All types of exhaust pipe consume more fuel at lower engine speed and decreases as engine speed increases up to 6000 RPM before it starts to increase as engine speed continuously increase. The same pattern also been presented by Obodeh & Ogbor (2009) and Mohd Faisal et al. (2013).

Standard exhaust consumes less fuel at 5000 RPM which is 277.927 g/kW. Low BSFC shows saving in fuel consumption by the engine. Thus the standard exhaust length is the most efficient exhaust. Although there are only 0.31% percentage different was observed as compared to the short exhaust length that produced the second lowest BSFC value.

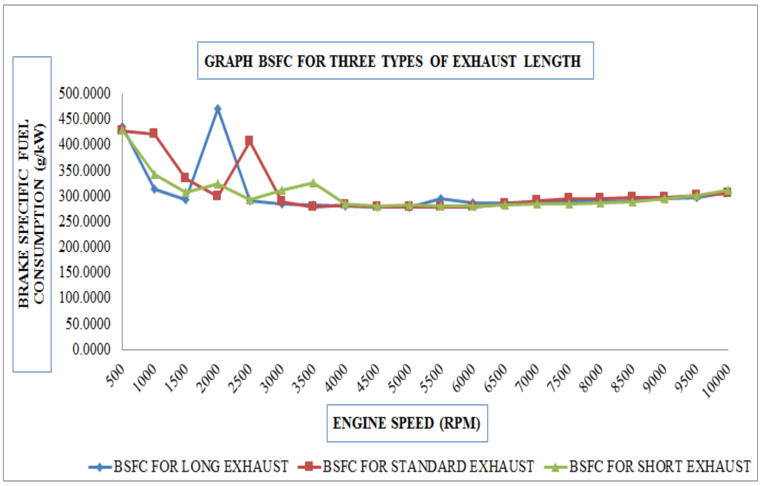

Figure 3: The result for Brake Specific Fuel Consumption in simulation

The exhaust emissions results produced by GT-Power simulation study were presented in the Figures 4 to 6 in the following sub-section. Three different exhaust sizes were set as variable in this simulation study. Emissions results that have been focused on are Carbon Dioxide, Carbon Monoxide and Hydrocarbon.

Figure 4.4 depicts the Carbon Dioxide (CO_2) emission emitted by different lengths of exhaust pipe. All types produced high CO_2 emission at lower engine speeds and this value decreases as engine speed increases up to 5000 RPM. CO_2 slightly increases as engine speed increases up to 10000 RPM. Obodeh & Ogbor (2009) in their study also produced the same pattern.

The highest value of CO_2 was produced by long exhaust pipe at an engine speed of 500 RPM, while the lowest CO_2 level was produced by the standard exhaust pipe at 4500 RPM. Based on study that has been conducted by Bagri & Chaube (2013), it shows that CO_2 level would decrease with the increasing of engine speed. Based on this simulation study, standard exhaust pipe produced the lowest CO_2.

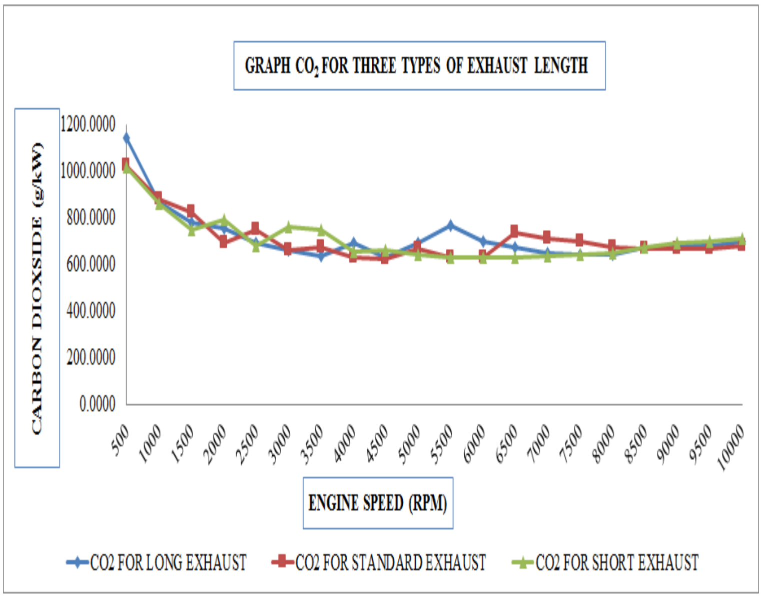

Figure 4: The result for Carbon Dioxide in simulation

Figure 5 shows the simulation results for Carbon Monoxide (CO) for three types of exhaust pipe. Based on the figure, CO level for three types of exhaust pipe is not structured at all engine speeds range. Standard and short exhaust pipes produced low CO level as compared to the long exhaust pipe at 500 RPM. At 10,000 RPM, all types of exhaust produced high CO level. CO is also a contaminated gas resulted from the combustion process inside the engine. Production of high carbon monoxide represents an inefficient engine.

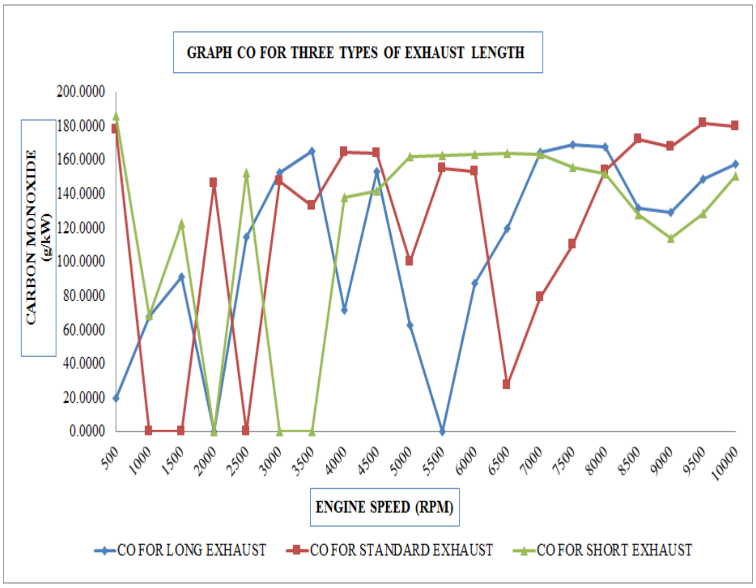

Figure 5: The result for Carbon Monoxide in simulation

Hydrocarbon (HC) is one of the pollution from the engine. Figure 4.6 depicts the simulation result of HC for three types of exhaust pipe. It can be seen that, short exhaust pipe produced the highest amount of HC; while the lowest was produced by the long exhaust pipe at all engine speeds. At the beginning engine speed, all types of exhaust produced high HC. Mohsin & Majid (2013) and Obodeh & Ogbor (2009) also obtained the same finding. From the simulation study, long exhaust pipe produced small or the lowest amount of the HC.

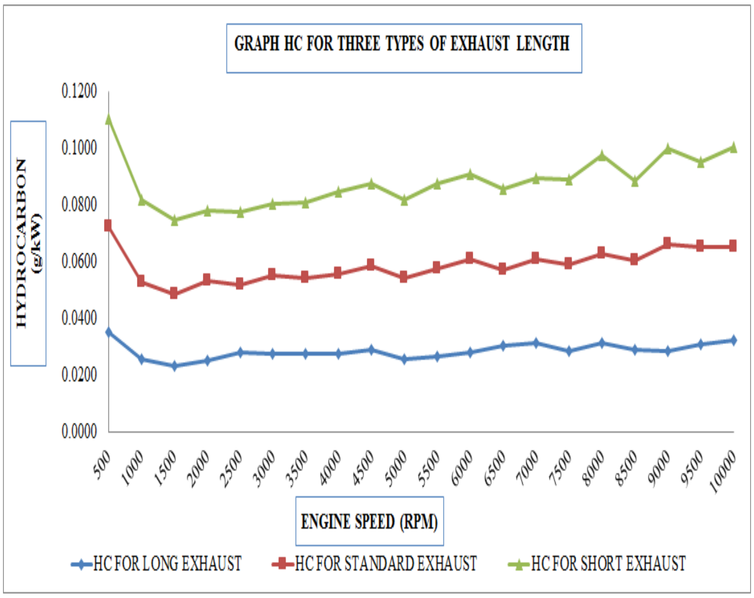

Figure 6: Hydrocarbons for three types of exhaust

V. CONCLUSION

The optimum length of exhaust manifold for achieving good performance using GT-Power software was justified and the effect of different lengths of exhaust manifold to the performances of motorcycle engine has been investigated. There are three types of different length of exhaust were used for the simulation process using GT- Power software.

For the simulation process using GT-Power, there are three types of performance of engine are Brake Power, Brake Mean Effective Pressure and Brake Specific Fuel Consumption have been studied. The highest Brake Power produced by the long exhaust at the highest speed. Brake Mean Effective Pressure achieved maximum value by the short exhaust at the engine speed of 8500 RPM. For the Brake Specific Fuel Consumption, the lowest value was produced by the standard exhaust at 5000 RPM. There are three types of gas that had been reviewed in this simulation study, which are carbon dioxide, carbon monoxide and hydrocarbon. Lowest carbon dioxide was produced by the standard exhaust at low engine speed – 500 RPM, and at the highest speed of 10000 RPM. Carbon Monoxide produces highest at short and standard exhaust with low speed 500 RPM. Standard exhaust was observed to produce the lowest hydrocarbon at all engine speeds.

ACKNOWLEDGEMENTS

An acknowledgement section may be presented after the conclusion, if desired.

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