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ANALYSIS OF ADDITION OF A TURBULATOR IN THE INTAKE MANIFOLD ON FUEL CONSUMPTION AND EXHAUST GAS EMMISSIONS OF CO AND HC ON THE LPG-FUELED 4-TROKES MOTORCYCLE

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KEYWORDS

"LPG", "Turbulator", "Exhaust Gas Emission", "Fuel Consumption"

ABSTRACT

Liquefied Petroleum Gas (LPG) is a derivatives of crude oil that contains several methane, butane, and the other hydrocarbon's product. Liquefied Petroleum Gas can be utilized as a vehicle fuel because of its inexpensiveness. The use of LPG as a vehicle fuel can be optimized with adding turbulator in the intake manifold. With the addition of a turbulator, the exhaust emission can be reduced and the fuel consumption of a LPG-fueled motorcycle become more efficient. The objectives of this research are: (1) Investigate the angle of inclination of turbulator blades which generates lowest exhaust gas emissions' of CO and HC on the LPG-fueled 4-strokes motorcycle. Investigate the angle of inclination of turbulator blades which generates the most efficient fuel consumption on the LPG-fueled 4-strokes motorcycle. This research used the 2006 Honda Supra 125 D as the sample. Variable used in this research is the addition of turbulator in the intake manifold with the variation of 30°, 45°, and 60° blades inclination angle. The result showed that the addition of a 30° turbulator can reduce the fuel consumption of LPG fuel with the result of 14,75 g/km. Meanwhile, using pertalite can consume 20 g/km. This also showed that the addition of a turbulator is more efficient than using refined fuel oil. The addition of a 45° turbulator resulting the most environmentally friendly with the exhaust emission result of 0,14% CO and 995,67 ppm HC.

INTRODUCTION

The population of motorized vehicles continues to increase every year. In Indonesia, at the least 5 years the population of motorized vehicles especially motorcycles increased by 24.114.205 units and will be continuously increased every year. Meanwhile, the existence of fossil fuel in the nature are very finite. The limited quantity of the fossil fuel cannot balance the need of fossil fuel. Because of that we need an alternative to substitute the use of petrol fuel to overcome the extinction of the fossil fuel.

One of substance that can be used to substitute petrol fuel especially as a vehicle fuel is Liquefied Petroleum Gas (LPG). LPG can be considered to replace petrol fuel because of its price that very cheap compared to the petroleum fuel. Besides that, LPG fuel also emits the environmentally friendly of exhaust emission. A lot of research has been done in the use of LPG fuels as the vehicle fuels.

One of the research that conducted by Suyabodha (2017) proved that in the real-time condition, the fuel consumption of LPG-fueled vehicle is lower than fuel consumption of petrol fuel. On the other study conducted by Chitragar, Shivaprasad, Nayak, Bedar, & Kumar (2016) declared that LPG can be recommended as an alternative

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fuel to substitute the use of petrol gas fuel. According to a study conducted by Usman et al., (2020) the use of LPG can reduce 21%, 9%, and 21% the amount of produced CO,CO_2, and hydrocarbon that doesn't ignited respectively.

In an attempt to optimize the use of LPG, the LPG-fueled vehicle can be modified like changing ignition timing, enlarge pilot jet diameter, and also adding turbulator in the intake manifold. Turbulator is a device that can change laminar flow to turbulent flow. The turbulence of a flow can affect the homogeneity of the flow, which means the ignition quality is better. Therefore, the exhaust emission that produced by vehicle can be better and the fuel consumption can be more efficient. Turbulator construction is more like a propeller but the mechanism is very contrast. On the turbulator mechanism, turbulator creates a vortex to the flow that pass through turbulator that stays idle. This vortex can be created through turbulator because the fluids flow have enough velocity to pass the idle turbulator. Turbulator can be made by 3D printer or galvanic plate.

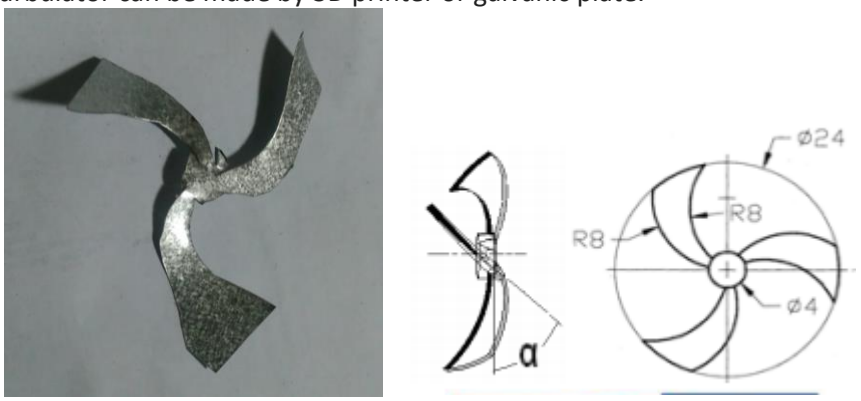

Figure 1. Turbulator Blade

According to study conducted by Wibowo & Siswantoro (2015) the use of turbulator can be affected the emission that produced by the vehicle and also increased the turbulence gradient in the intake manifold. On the other experiments that conducted by Surono, Winarno, & Alaudin (2012) addition of a turbulator can produce lower fuel consumption compared to the petrol vehicle.

The purposes of this research are to determine the angle of inclination of turbulator blades which generates lowest exhaust gas emissions' of CO and HC and to determine the angle of inclination of turbulator blades which consumes less fuel. This study compares a petrol-fueled motorcycle, a LPG-fueled motorcycle, and a LPG-fueled motorcycle with addition of turbulator.

RESEARCH METHODS

This research is a quantitative research with experimental methods. For the emission test, this research carried out at BLK Surakarta which located at Bhayangkara Street No.38, Panularan, Laweyan sub-district, Kota Surakarta. Meanwhile for the fuel consumption test carried out at a distance of 100 kilometers with a Surakarta-Yogyakarta-Surakarta with flat, uphill, downhill, bend, and rocky road conditions. The instrument used in this research are gas analyzer, digital scale, odometer, and tachometer. This research work principle is illustrated by Figure 2.

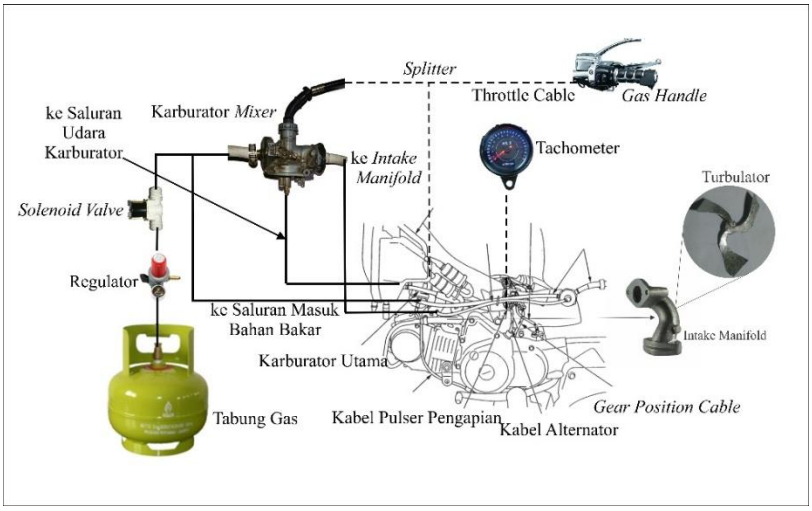

Figure 2. Work Principle Scheme

RESULTS AND DISCUSSION

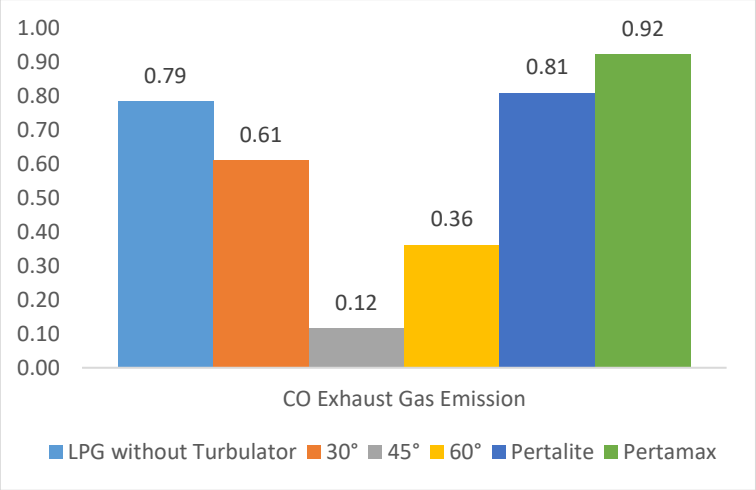

Figure 3. CO Exhaust Gas Emission (%)

From the Figure 3 above, 45° turbulator produces lowest CO Gas. The 45 LPG can produce less CO Gas compared to both pertalite and pertamax because LPG consist less carbon atom per energy units. The carbon atom is more reactive to the O_2 molecules. As the result of that, the production of CO_2 and Hydrocarbons is increasing. With the addition of turbulator can reduce the CO gas produced by vehicle. Compared to the LPG without turbulator that produces 0,79% CO Gas, the addition of 45° turbulator can reduce approximately 80% of CO Gas production.

The other variant of turbulator also give positive impact toward the quality of produced CO gas although not as significant as the 45° turbulator blades. Installation of turbulator can make the mixture of air and fuel flow more turbulent which caused the fuel and air mixture is more homogenous. This also makes the combustion process is more complete and leave less residual CO gas. The 30° Turbulator resulting 0,61% CO gas and the 45° turbulator produces 0,36% CO gas.

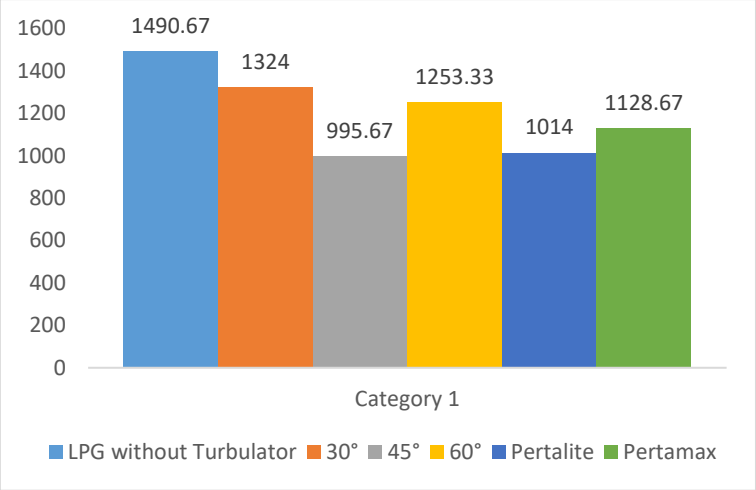

Figure 4. HC Exhaust Gas Emission (ppm)

Based from Figure 4, LPG-fueled motorcycle with addition of 45° turbulator produces the lowest HC exhaust gas emission with the result of 995,67 ppm. This result is having slightly difference compared to the Pertalite fuel that produces 1014 ppm of HC. And LPG-motorcycle without installed turbulator produced highest amount of HC gas. This can be caused by flame speed of the LPG fuel that slower than the both petrol fuels. This makes the unburned LPG fuel which contains HC comes out along with the residue of the combustion process and then detected by gas analyzer (Mahmud & Sungkono, 2015).

The installation of turbulator blades can also reduce the HC gas produced by LPG fueled vehicle. Same case as in the CO gas emission, mixture homogeneity can make the combustion process more complete. To obtain better hydrocarbon exhaust gas emission results, it can be done with some other modifications like changing the ignition timing, increasing engine compression, etc.

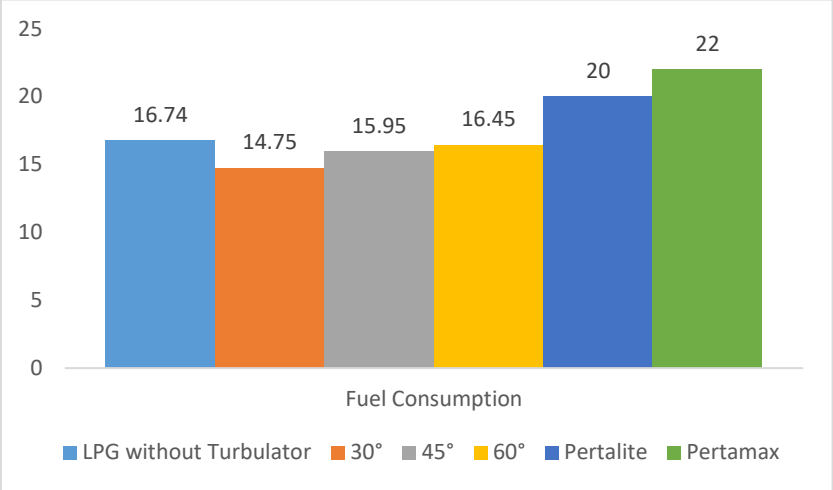

Figure 5. Fuel Consumption (g/km)

From the Figure 5 above, showed that LPG-fueled vehicle is more efficient than the both petrol fuels. LPG-fuels only takes of 16,74 grams to reach 1 kilometer. Meanwhile, Pertalite needs 20 grams and Pertamax needs 22 grams to reach 1 kilometer. This can be caused by the phase of LPG that in a gas state which causes the combustion is easier to be done. The other factor that caused LPG is more efficient than petrol fuel is the oxidation of LPG is faster than the petrol fuels (Rohmat, 2018).

The installation of turbulator blades also give positive impact toward fuel consumption of LPG-fueled vehicle. The 30° turbulator is consuming the lowest fuel which only uses 14,75 grams to reach 1 kilometer. Followed by the 45° turbulator and 60° turbulator that resulting fuel consumption of 15,95 grams and 16,45 grams respectively. The vortex caused by turbulator can reduce the volume of fuel that flows to the cylinder. Homogeneity of the mixture also give contribution to low fuel consumption.

CONCLUSION

Based on the results of research and data analysis, we can conclude that Addition of a turbulator with 45° blades angle inclination emits the lowest exhaust gas emission of an LPG-fueled 4-strokes motorcycle with the average result of 0,14 % CO and 995,67 ppm HC. Addition of a turbulator with 30° blades angle inclination generates the most efficient fuel consumption of an LPG-fueled 4-strokes motorcycle with the average fuel consumption result 14,75 gram/km.

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