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AIR OPTIMIZATION ON MOTORCYCLE INTAKE MANIFOLD TOWARDS WORK PERFORMANCE AND EXHAUST GAS EMISSIONS

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ABSTRACT
The objective of this study is to enhance engine performance and reduce exhaust emissions of a 200 cc motorcycle engine by modifying the intake manifold through the integration of a spiral turbine. The background of this research is the increasing exhaust emissions of motor vehicles which are one of the main causes of air pollution, as well as the low combustion efficiency of conventional motorcycle engines. The literature review shows that the homogeneity of the air and fuel mixture has a significant role in combustion efficiency and engine performance. The spiral turbine is designed to create a swirling airflow that improves the mixing of fuel and air before entering the combustion chamber. The research method used is an experimental study by testing engine performance using the Dyno Test and analyzing exhaust emissions at various engine speed variations. The parameters tested include torque, power, engine efficiency, and exhaust emissions such as CO, HC, and NOx.The results showed that the installation of a spiral turbine with an inclination angle of 40° and 10 blades provided a significant increase in engine torque and power. In addition, vehicle exhaust emissions, particularly CO and HC levels, were successfully minimized. The prospect of this research is the development of a simple and economical technology to improve engine performance while supporting environmentally friendly air pollution reduction efforts.

Keywords: combustion optimization; engine performance; exhaust emissions; intake manifold spiral turbine

INTRODUCTION
BPS data shows that the number of motorcycles in Indonesia was 120,042,298 units in 2021 and increased to 125,305,332 in 2022 (https://www.bps.go.id/, 2024). With the increase in the number of motorcycles, the level of exhaust emissions and fuel use is also increasing. Citing dataindonesi.id article, Indonesia is the largest motorcycle market in ASEAN, the number of motorcycles in Indonesia on August 29, 2024 is 137,350,299 units (Mustajab, 2024). Motor vehicles are currently still dependent on fuel oil (Sasmita, Reza, Elystia, & Syarah Adriana, 2022) and to reduce dependence on it, humans will continue to develop to get the best possible fuel oil efficiency and improve the performance of the engine and produce environmentally friendly exhaust emissions. Incomplete combustion will result in more wasteful fuel consumption (Khoir & Marsudi, 2011).

At this time, the development of technology and science has increased sharply, as it is known that new technologies have emerged, so that nowadays they are developing very quickly. New inventions in this field are not entirely new inventions, but are developments of previous inventions or are refinements of previous inventions or simply provide additional tools, without having to change the construction of existing machines including the tools used to improve the performance of the machine called the Cyclone/Vortex (Samokhvalov, 1979). Internal combustion engines according to the process are divided into two, namely perfect combustion (normal) and imperfect combustion (abnormal) (Muchammad, 2007). Incomplete combustion is caused by the fuel entering to the combustion chamber not entirely burning, because during the process of mixing fuel and air is not homogeneous.

The use of a spiral turbine is an additional tool used in the combustion process in an engine that functions to make the air that will flow to the carburetor and cylinder of the combustion chamber rotate/swirl (Kim, Edirisinghe, Yang, Gunawardane, & Lee, 2021). This tool is the invention of Mr. DR. M Sei Young Kim, from Korea. To get a more homogeneous mixture of air and fuel, it can be done by creating an air flow vortex from the end of the intake manifold or inlet, so that when the fuel and air that enters through the intake manifold form a turbulent flow and congestion occurs. This study aims to determine the influence of spiral turbines on engine performance and vehicle exhaust emission results, power and torque most efficiently with environmentally friendly exhaust emission results.

METHOD

In data collection, the method used is to conduct a trial using a sample that has been determined as the object of this research. The location of the data collection is located at the Indonesian Land Transportation Polytechnic - STTD, Motor Vehicle Testing and Control Building Jl. Raya Setu No 89 Cibuntu, Cibitung, Bekasi Regency. The study was conducted in 16 (sixteen weeks). With the division of 4 (four) activities, namely data collection (literature study), field survey, data processing, and report preparation.

Table 1.
Research Time

Yes	Activities	Time of implementation (week-)															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Data collection (literature study)																
2	Field surveys																
3	Data processing																
4	Report preparation																

Source: Researcher 2024

Data Collection Methods

The method of collecting data for literature studies is a search for literature sourced from books, media, experts or from the results of other people's research that aims to compile a theoretical basis (Sugiyono, 2013). This literature study studies spiral turbines, homogeneous fuel mixtures, vehicle exhaust emissions, power and torque in internal combustion vehicles.
The method of collecting test data in the laboratory is needed in discussing research problems, namely about the experimental study of the installation of spiral turbine devices in motor vehicles and its effect on the performance of engine performance and the resulting exhaust gas emissions.

The data collection variables consist of 3 (three) variables:

1. Independent Variables:
   a. 40° Spiral Turbine spoon angle variation;
   b. The total number of tablespoons is 10 tablespoons;
   c. Fuel with an octane rating of RON 92.

2. Bound Variables:
   a. Torque (T)
   b. Effective power (P);
   c. Exhaust Gas Emissions (CO, HC, CO2, and O2);
3. Variable Control:
   a. Honda Tiger Motorcycle in 2010;
   b. Engine oil temperature 60 degrees - 70 degrees C (engine working temperature);
   c. Engine rotation of 1500 rpm to 10,000 rpm, with a rotation range of 500 rpm;
   d. Room temperature 25 degrees - 40 degrees C;
   e. Air humidity (humidity) 25% - 60%.
4. The tools used are as follows:
   a. Tool set, a tool for attaching a spiral turbine to an air duct leading to the intake.
   b. Stopwatch, to measure time.
   c. Tachometer, to measure the rotation of the machine.
   d. Blower, to maintain the working temperature of the machine.
   e. Emissions CAPELEC 3201 tester, to test the exhaust gas emission content
5. The materials used are as follows:
   a. Honda Tiger Motorcycle in 2010,
   b. 40 degree 10 spoon angle spiral turbine,
   c. Cotton cloth;
   d. Glove;
   e. Mask.

Turbin Spiral

This spiral turbine is an additional device that functions to form an air vortex that is placed on the air filter before entering the combustion chamber and also that is placed on the *intake manifold* channel according to the number of cylinders in the gasoline/diesel motor. In general, spiral turbines are made of stainless steel (aluminum) and have spoons to form a certain slope. A spiral turbine is an auxiliary device to the *internal combustion engine* to make the air flow that will enter the carburetor and combustion chamber cylinder rotate/swirl (Muchammad, 2007). Spiral turbine is an air compression technology that passes through the spiral turbine spoon to create a more focused vortex (Meiraga & Muhaji, 2013).

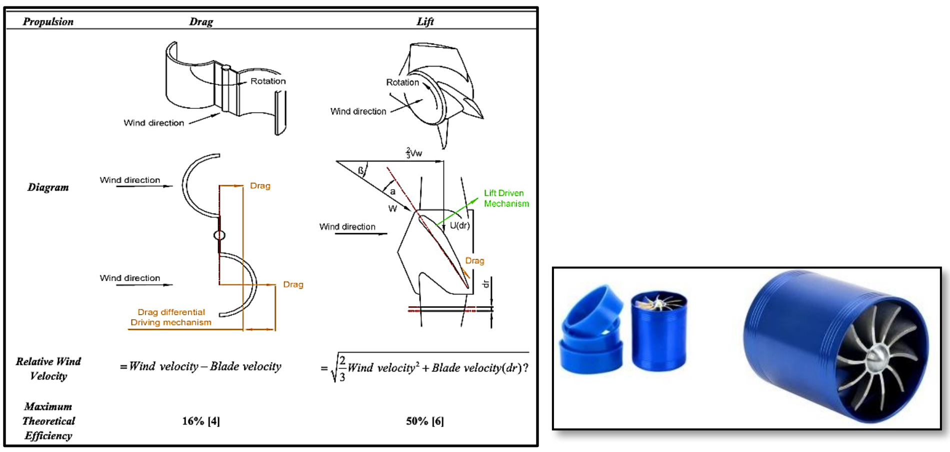

Figure 1. Illustration of Airflow On Spoon (Canra, Rahmi, & Haris, 2018) and Turbine Tool Spiral Blade Angle Tilt 40 Degree

The angle contained in the turbo spiral can be from 10o to 45o. Each change in the blade greatly affects the performance of the engine which has an impact on the intensity of turbulence and pressure drop. But in this study, a spoon angle with a slope of 400 was used, so it is expected

to form a *swirl* and form a homogeneous and optimal air mixture when mixed with fuel.
In this study, a spiral turbine with a diameter of 36 mm and a width of 20 mm was used, where the spiral turbine used 10 blades with an angle variation of 400. This is adjusted from the *intake manifold design* in the test material in the form of a 2010 Honda Tiger.

Technical Installation of Spiral Turbine

The assembly of the spiral turbine greatly affects the performance of the engine and the exhaust gas emissions produced, a homogeneous mixture of fuel and air before entering the combustion chamber must pass through the spiral turbine in order for *pressure drop* and turbulence to occur. Spiral turbine assembly on the Honda Tigger as shown in Figure 3.

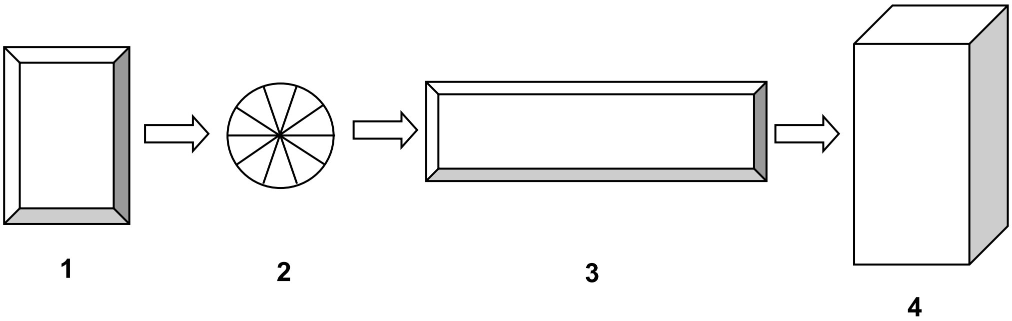

Figure 2. Spiral Turbine Assembly on Machine
Information: 1 = Air Filter
2 = Turbin spiral
3 = *Intake Manifold*
4 = Combustion Chamber/Cylinder

The spiral turbine is located in the inlate channel on the intake manifold. Converts the laminer flow (straight) before it enters the combustion chamber into a vortex flow (Khoir & Marsudi, 2011). This is so that the mixture of fuel and air can pass through a spiral turbine before heading to the intake manifold, so that in the intake manifold there is a turbulence flow and pressure drop, so that the mixture of air and fuel is more homogeneous and optimal before entering the combustion chamber.

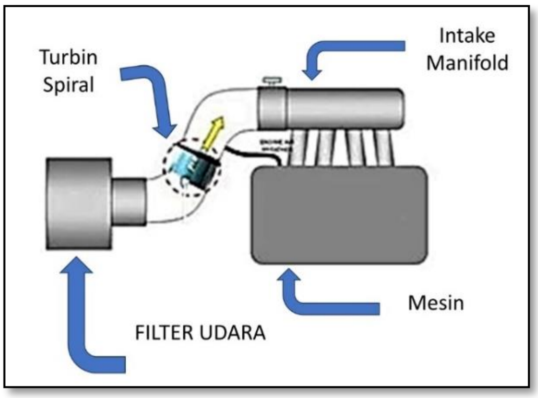

Figure 3 Application Design of Spiral Turbine Tool (Muchammad, 2007)

Figure 3 is an illustration of the application of the turbine tool from the air filter to the *intake manifold* which then the pressurized air is passed to the engine. The higher the engine rotation, the more air will enter with an increase in air pressure.

Analysis Method

The approach used in this study is an experimental method with a machine/measuring device, where in the data analysis method there are 2 stages of sampling on the research object, namely: The first stage is to test the exhaust gas emissions of the research object vehicle that are not equipped with a Spiral Turbine or equipped with a Spiral Turbine, by paying attention to the engine rotation (rpm), engine temepratur and the working environment, and safety, Occupational Health (K3) when collecting data. The concentration data of the substance content taken are Carbon Monoxide (CO), Hydrocarbon (HC), Carbon Dioxide (CO2), and Oxygen (O2).

The second stage is to collect Torque and Power data using turbines and without turbines.

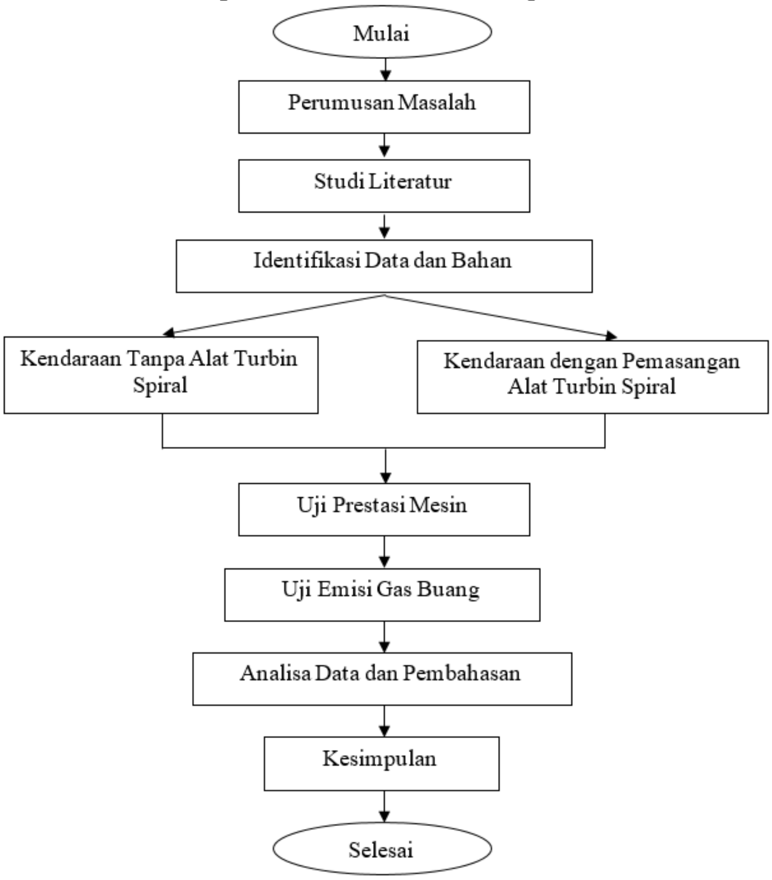

Figure 4. Research Flow Diagram.
Source : author

RESULT AND DISCUSSION

Measurement of exhaust gas emissions with concentrations of CO, CO2, HC, O2, is carried out on vehicles without the installation of a Spiral Turbine Device. From the results of 2 (two) Exhaust Gas Emission tests, namely emission tests using turbines and without spiral turbines. The table of average values of CO, CO2, HC and O2 emission concentrations is as follows:

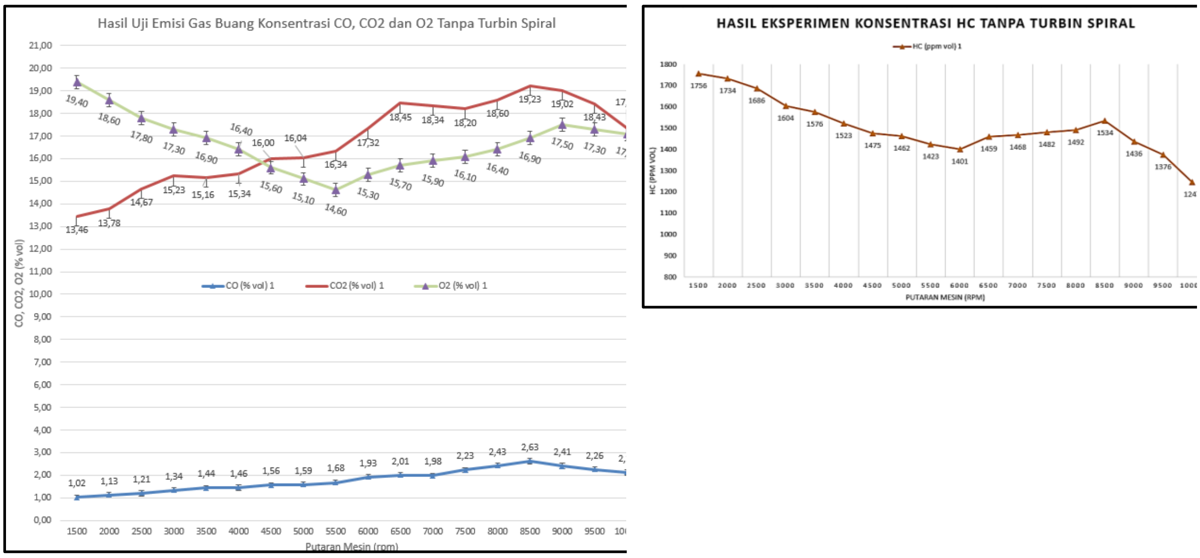

Figure 5. Graph of the measurement results of CO, CO2, O2 and HC without a Spiral Turbine.

In Figure 5, the CO level has increased continuously up to 8500 rpm with the highest CO value of 2.63%. CO2 levels also experienced a similar increase, at the beginning of the engine running, there was an increase to 18.45% at 6500 rpm and the highest level with a value of 19.23% at 8500 rpm. The O2 value decreased from the highest value of 19.40% at 1500 rpm to 5500 rpm again increased to 17.50% O2 level at 9000 rpm, and then decreased slowly. The concentration of HC contained in exhaust gas emissions, at the predetermined engine rotation of the vehicle, is shown in figure 3.1 of the graph of the results of the measurement of HC concentration without a spiral turbine. With the highest rate at 1756 ppm at 1500 rpm, the rate drops to 1401 ppm at 6000 rpm, then increases again to 1534 ppm at 8500 rpm, and the higher the rpm, the lower the HC level.

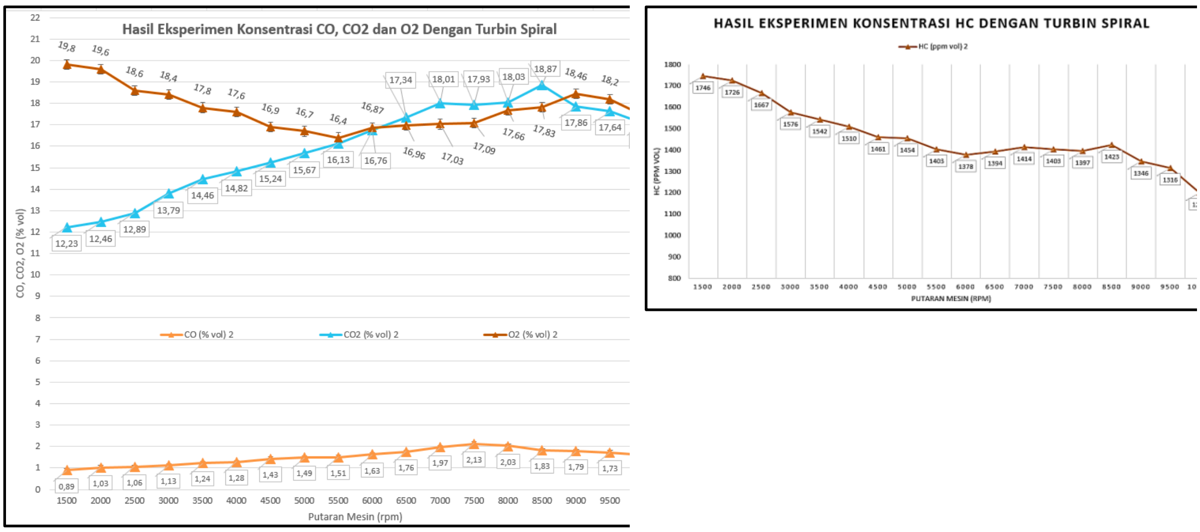

Figure 6. The graph of the measurement results of CO, CO2, O2, and HC is equipped with a Spiral Turbine.

The lowest CO content is 0.89 % vol at 1500 rpm, and the highest CO content is 2.13 % vol at 7500 rpm. The lowest CO2 level is 12.23 % vol at 1500 rpm, and the highest CO level is 18.87 % vol at 8500 rpm. The lowest HC level is 1201 ppm vol at 10,000 rpm, and the highest HC level is 1746 ppm vol at 1500 rpm. The lowest O2 level is 16.40% vol at 5500 rpm, the highest O2 level is 19.80% at 1500 rpm.

Vehicle Performance Test

From the results of 2 (two) attempts to test the Engine Performance, the table of the average values of the Torque Test (T) in Nm and the Effective Power Test (P) in HP, is as follows:

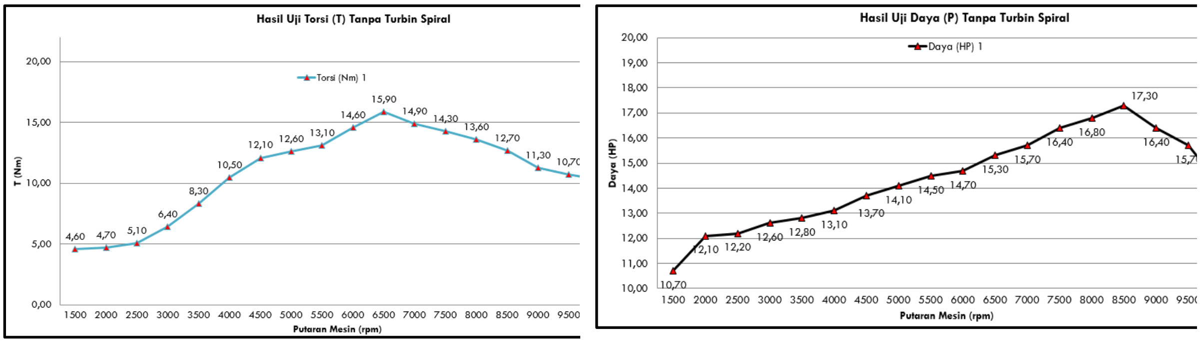

Figure 7 Graph of the performance of Torque and Power without Spiral Turbine Tools

Figure 7 of the graph shows the torque level produced at the initial engine rotation measurement of 1500 rpm torque of 4.60 Nm and increased as the engine rpm increased, and reached the highest torque level of 15.90 Nm at 6500 rpm and torque decreased to 10.30 Nm at 10,000 rpm. The power that can be read in the measurements produced is the lowest power of 10.70 HP at 1500 rpm and increases along with engine rotation, the highest power is reached at 17.30 HP at 8500 rpm engine rotation then the power decreases gradually until the engine rotation is 10,000 rpm at a value of 14.10 HP. The thing that can affect high engine power is the efficient intake of air and fuel mixture can affect engine power.

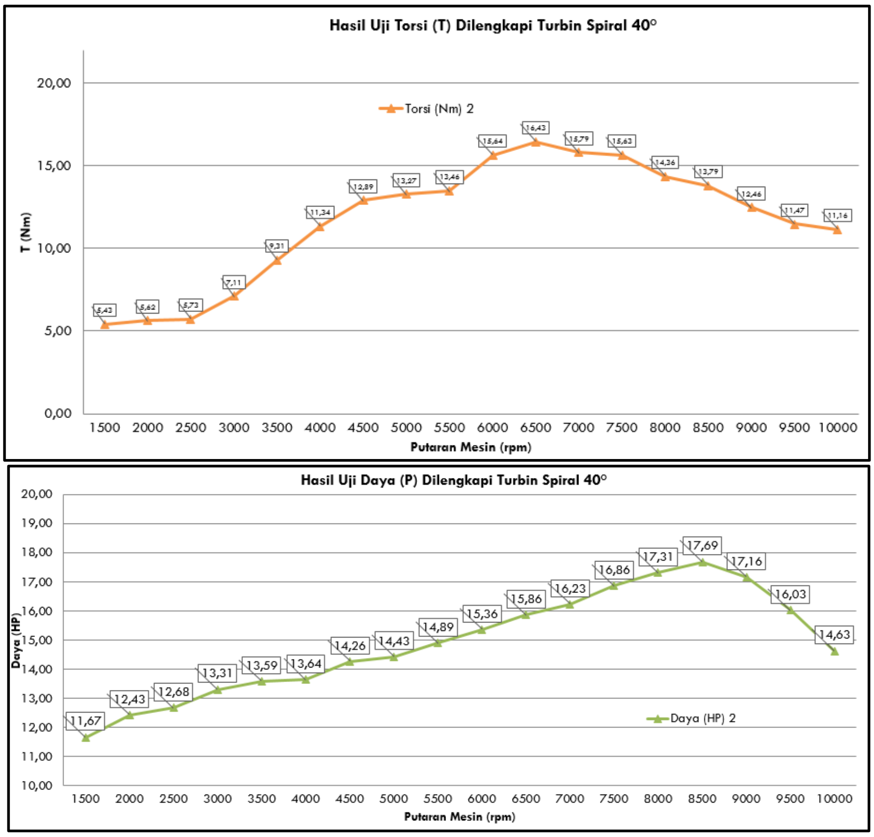

Figure 8. Graph of the performance results of Torque and Power of the Spiral Turbine Tool

In the data display of Figure 8 Graph, the torque of the test vehicle produced using a 40° spoon angle spiral turbine tool shows the lowest Torque (T) value of 5.43 Nm when the engine revs are at 1500 rpm, and the highest Torque (T) value is 16.43 Nm at 6500 rpm. In the data display of Figure 4.8 Graph, the power (P) readability value of the test vehicle with the highest value of Power, which is 17.69 HP, is produced at 8500 rpm engine rotation, while the lowest Power (P) value is 11.67 HP at 1500 rpm engine rotation.

CONCLUSION

1. In the Exhaust Gas Emission test, data was obtained that the lowest CO level was found at low engine rotation of 1500 rpm, either with or without a Spiral Turbine device. The difference is that after the installation of the Spiral Turbine, the CO value drops from 1.02 %vol to 0.89 %vol with a percentage decrease of 12.7%.
2. The highest CO gas content value is 2.63 %vol at 8500 rpm engine rotation without a spiral turbine, when equipped with a spiral turbine the CO gas content drops to 2.13 %vol 7500 rpm, according to and according to the quality standards of the Minister of the Environment Regulation No. 8 of 2023 the CO level is still within the threshold, for 2-wheeled vehicles in 2010 production the maximum CO gas is 4 %vol
3. The results of the Exhaust Gas Emission test found the highest HC rate value of 1756 ppmvol at 1500 rpm intake manifold engine rotation without being equipped with a Spiral Turbine. When equipped with the Trubin Spiral, the highest HC gas concentration level with a value of 1746 ppmvol decreased by 0.5% from the highest HC gas concentration value. This is still within the quality standard threshold of 1800 ppmvol.
4. The lowest HC gas concentration value with a concentration value of 1247 ppmvol without using a Spiral Turbine, and the lowest HC gas concentration value when equipped with a Spiral Turbine is 1201 ppmvol.
5. The lowest CO2 gas concentration value is 13.46 %vol at 1500 rpm engine rotation without a Spiral Turbine, when equipped with a Spiral Turbine the concentration value drops to 12.23 %vol at 1500 rpm engine rotation. Meanwhile, the highest CO2 gas level without a Spiral Turbine is 19.23 %vol at 8500 rpm engine rotation and when equipped with a Spiran Turbine drops to 18.87 %vol at 8500 rpm engine rotation. However, the maximum value of CO2 gas concentration levels has not been stated in the quality standards of PermenLH 8 of 2023.
6. The lowest O2 gas content is 14.6 %vol at 5500 rpm engine rotation without a Spiral Turbine, the highest O2 gas concentration level is 19.4 %vol at 1500 rpm engine rotation. The concentration of O2 gas increased after being equipped with a Spiral Turbine to 19.8 %vol at 1500 rpm engine rotation and the lowest value was 16.4 %vol at 5500 rpm.
7. The engine performance test showed the largest Power (P) data without a Spiral Turbine which was 17.30 HP at 8500 rpm engine rotation and experienced an increase in Power when equipped with a Spiral Turbine to 17.69 HP at 8500 rpm engine rotation. This can happen because the mixture of air and fuel is more homogeneous and also with a larger capacity with the increasing mixture of fuel and air that enters the space, the greater the power produced (McAfee, 2002).
8. The highest Torque value in the Performance Test of a vehicle without a Spiral Turbine is at 15.90 Nm at 6500 rpm. Experiencing an increase in Torque value when equipped with a Spiral Turbine of 16.43 Nm at 6500 rpm engine rotation, this correlates with an increase in power when equipped with a Spiral Turbine.
9. Based on experiments that have been carried out, modifications to motor vehicles can have a positive impact on vehicle performance/performance and its relation to exhaust emissions. So that in the future it is necessary to do further research/experiment with more diverse objects, variations in the amount of CC of vehicles, including for four-wheeled vehicles.

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