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# Analysis of the Performance of the Liquid Cooling System on the Thermal Efficiency of Honda Vario 125 Motorcycle

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**ABSTRACT**

This study discusses the performance of the liquid cooling system on the Honda Vario 125 motorcycle to understand its effect on the thermal efficiency of the engine during operation. The liquid cooling system plays a role in keeping the engine temperature stable, so that the combustion process takes place more effectively. The test was carried out by taking data on cylinder head temperature, coolant temperature, and fuel consumption at various engine rev levels. The data obtained is analyzed to assess the ability of the cooling system to reduce temperature rise and keep the engine at an optimal working range. The results show that at medium to high cycles, liquid cooling systems are able to maintain temperature stability with relatively small fluctuations. These more stable thermal conditions contribute to improved combustion efficiency which is reflected in decreased specific fuel consumption and increased thermal efficiency. These findings indicate that the cooling system design on the Honda Vario 125 has adequate capabilities to maintain consistent engine performance, especially in daily use with load variations. This study can be a technical reference in the development of motor vehicle cooling systems.

**KEY WORDS:** *Honda Vario; liquid cooling system; engine temperature; thermal performance; efficiency*

**NOMENCLATURE**

| | |
|---|---|
| $C_p$ | *Heat type of refrigerant (kJ/kg· (K)* |
| $\dot{Q}$ | *Heat transfer rate (W)* |
| $\dot{m}$ | *Coolant mass flow rate (kg/s)* |
| $T_{in}$ | *Radiator inlet coolant temperature (°C)* |
| $T_{out}$ | *Radiator outlet coolant temperature (°C)* |
| $\eta_{th}$ | *Engine thermal efficiency (%)* |
| *SFC* | *Specific fuel consumption (g/kWh)* |
| *Rpm* | *Machine revolutions per minute* |
| $P_{out}$ | *Engine output power (W)* |
| $\dot{m}_f$ | *Fuel mass flow rate (kg/s)* |

## 1.0 INTRODUCTION

Automatic scooter motorcycles are one of the most widely used types of motor vehicles in Indonesia because they have operational characteristics that are practical, efficient, and suitable for daily mobility. The Honda Vario 125 is one of the standout models in its class thanks to the use of a liquid cooling system designed to maintain the stability of engine temperatures during operation [1]. This cooling system functions to flow coolant through a certain path to absorb and dissipate the heat generated from the combustion process as well as internal friction.

The thermal conditions of the engine have a significant influence on the performance and efficiency of combustion. Too high a temperature can accelerate the degradation of lubricants, decrease component efficiency, and even cause combustion instability. Conversely, temperatures that are too low can inhibit the fuel evaporation process, reducing thermal efficiency [2]. Therefore, the ability of the cooling system to maintain an optimal working temperature is an important aspect that needs to be analyzed technically.

The Honda Vario 125 adopts a compact radiator and active circulation through a water pump, which is expected to be able to provide more stable cooling performance than conventional air-cooling systems [3]. However, the effectiveness of such systems under various operating conditions, particularly on rotation and load variations, needs to be further reviewed through an experimental approach. This analysis is important to understand the relationship between temperature stability and fuel consumption and the overall thermal efficiency of the engine.

This study aims to evaluate the performance characteristics of the liquid cooling system in the Honda Vario 125 and assess its contribution to the thermal efficiency of the engine. The results of the study are expected to provide a more comprehensive picture of the ability of the cooling system to support vehicle performance in daily use.

## 2.0 METHODOLOGY

The methodology of this research is prepared to ensure that the entire process of data collection, measurement, and analysis is carried out systematically and measurably. The approach used is experimental, namely by conducting direct tests on Honda Vario 125 motorcycles to assess the performance of the liquid cooling system under various operating conditions. The entire test series was conducted in a controlled environment to minimize the influence of external factors that could affect the results.

The research process begins with the preparation stage, including checking the condition of the engine, installing temperature sensors, and calibrating measuring instruments. After the preparation is complete, the motor is run at several engine rotation levels to record data on cylinder head temperature, coolant temperature before and after the radiator, and fuel consumption. The data is recorded directly using a digital recording device to obtain consistent and accurate measurement results.

In addition to taking temperature and fuel data, the study also involves calculating the heat transfer rate and thermal efficiency of the engine. The calculation is carried out using engineering equations that are in accordance with the principles of heat transfer and energy conversion, so that the results of the analysis can describe the ability of the cooling system to maintain the thermal stability of the engine. All the steps in this methodology are arranged so that they can be replicated by other researchers and provide a comprehensive technical overview of the performance of the liquid cooling system on the Honda Vario 125.

### 2.1 Testing Equipment and Materials

This sub-chapter describes all equipment, measuring instruments, and materials used during the research process. Each tool is selected based on its level of accuracy, stability, and suitability to support data collection related to the performance of the liquid cooling system on the Honda Vario 125.

The Honda Vario 125 motorcycle was used as the main object of the research because its liquid cooling system has been designed integrated with radiators and circulation pumps. The condition of the engine is checked first to ensure that all components are working normally and that there are no leaks in the cooling system, so that the test results can reflect the performance of the machine under the manufacturer's standard conditions.

Measuring instruments in the form of K-type thermocouples are installed at several measurement points to monitor temperature changes in real-time. This type of thermocouple was chosen because it has a fast response to temperature fluctuations and is able to work at a temperature range that suits the conditions of the internal combustion engine. To record temperature data continuously, a multichannel data logger is used, which allows the recording of temperature from multiple sensors simultaneously.

During the test, the engine is operated using a roller-type dynamometer which functions to keep the engine rotation stable in each test. The use of a dynamometer allows for consistent rotation control so that comparisons between rpm conditions can be made accurately. Meanwhile, fuel consumption is measured using a high-precision digital scale to determine changes in fuel mass before and after the test.

In addition to the main equipment, supporting devices such as digital tachometers, stopwatches, and computer devices for data processing are also used. All instruments have gone through an initial calibration process to ensure that the measurement results are accurate and scientifically accountable.

### 2.2 Research Flow Diagram

The research flow chart is compiled to describe the sequence of processes carried out systematically during the research. The preparation of this flow chart aims to provide a clear understanding of the steps of the experiment, from the preparation stage to the final analysis. With a structured flow, research can be carried out consistently, easily replicated, and minimizes the possibility of procedural errors.

The first stage of the research begins with preparing all equipment, including checking the condition of the machine, installing sensors, and calibrating measuring instruments. Once the equipment is ready, the process continues with the operation of the machine at idle to ensure the sensor has read the initial temperature correctly. Tests were then carried out at several engine rev levels, namely 3000 rpm, 5000 rpm, 7000 rpm, and 8000 rpm. In each rotation condition, data on cylinder head temperature, coolant temperature in and out of radiator, and fuel consumption are recorded periodically using a data logger.

After all the data is collected, the next stage is data processing which includes the calculation of heat transfer rates, specific fuel consumption, and engine thermal efficiency using predetermined engineering equations. The data obtained was then analyzed to see the relationship between engine rotation variations and the performance of the liquid cooling system. The results of the analysis were used to draw conclusions regarding the effectiveness of the cooling system in maintaining the stability of the machine's work.

The horizontal axis wind turbine geometry model used in this study consists of three blades with airfoil variations and pitch angles designed using CAD software. The rotor diameter is set at 1 meter with an adjusted blade length ratio to ensure suitability for the simulated domain. The selection of airfoil shapes is made based on the characteristics of lift and drag suitable for low to medium wind speed applications.

### 2.3 Machine Temperature Measurement Procedure

The engine temperature measurement procedure was carried out to evaluate the ability of the liquid cooling system in maintaining the stability of the Honda Vario 125 engine working temperature [4]. Before the test begins, the engine is inspected to ensure that there are no leaks in the cooling system and that all components are in normal condition. The engine is then run at idle for a few minutes until it reaches a stable initial temperature, so that measurements can be taken at representative conditions.

The K-type thermocouple sensor is installed at several predetermined measurement points, namely the cylinder head, radiator inlet, and radiator outlet (outlet). The placement of sensors at these points aims to obtain an overview of the temperature distribution and the effectiveness of heat transfer that occurs in the cooling system. The entire sensor is connected to a data logger to continuously record temperature data during the test.

The test is carried out by operating the engine at several rev levels, namely 3000 rpm, 5000 rpm, 7000 rpm, and 8000 rpm. Each revolution is maintained for a certain period of time in order for the engine temperature to reach a stable condition. Temperature data is recorded at the same time interval at each round condition to ensure data uniformity. The test was repeated several times to obtain an average score and reduce the influence of fluctuations in environmental conditions.

### 2.4 Fuel Consumption Measurement

Fuel consumption measurements are carried out to determine the level of efficiency of engine fuel use at various rotation conditions and its relation to the stability of the engine's working temperature. The measurement method used is the mass method, because it is considered to have a better level of accuracy than the volumetric method, especially for tests in a relatively short duration.

Before the test begins, the fuel is placed on a measuring container connected to the engine's fuel supply system. The initial mass of fuel is weighed using a high-precision digital scale. The engine is then run at a certain speed according to a predetermined variation, i.e. 3000 rpm, 5000 rpm, 7000 rpm, and 8000 rpm, during the same time interval in each test. After the duration of the test is completed, the final mass of the fuel is re-weighed to determine the difference in the mass of the fuel used.

The difference in fuel mass is used to calculate the flow rate of the fuel mass. This flow rate value is then used in the calculation of *Specific Fuel Consumption* (SFC) by considering the engine output power at each revolution. Fuel consumption testing is carried out repeatedly to obtain a more representative average value and reduce the influence of measurement errors. The fuel consumption data obtained was then analyzed along with engine temperature data to see the relationship between working temperature stability and fuel use efficiency. The results of these measurements are an important parameter in the evaluation of the thermal efficiency of the machine which is discussed in the next stage of analysis.

### 2.5 Calculation of Cooling System Heat Transfer Rate

The calculation of the heat transfer rate is carried out to determine the ability of the liquid cooling system to dissipate the heat generated by the engine during the combustion process. The heat released by the engine is absorbed by the *coolant* and then discharged through the radiator into the environment. Therefore, the large rate of heat transfer is the main indicator of the effectiveness of the cooling system.

The heat transfer rate is calculated based on the change in the coolant temperature between the radiator inlet and outlet. The equation used refers to the basic principle of convection heat transfer in fluids, namely:

$$\dot{Q} = \dot{m} \times Cp \times (T_{in} - T_{out})$$

Where:

| | |
|---|---|
| $\dot{Q}$ | is the heat transfer rate (W), |
| $\dot{m}$ | is the mass flow rate of the coolant (kg/s), |
| $Cp$ | is the heat of the coolant type (kJ/kg· K), |
| $T_{in}$ | is the temperature of the coolant inlet of the radiator |
| $T_{out}$ | is the temperature of the coolant out of the radiator |

The $T_{in}$ and $T_{out}$ temperature values were obtained from the results of measurements using a thermocouple sensor in the previous procedure. The coolant mass flow rate is determined based on the specifications of the cooling pump and the assumption of stable flow conditions during testing. Calculations were made at each variation of engine rotation to see the effect of increased thermal load on the cooling system's capabilities [5].

The results of the calculation of the heat transfer rate are then compared between engine revolutions to analyze the tendency of increased heat that must be dissipated by the radiator. The higher the $\dot{Q}$ value, indicates the greater the heat released by the engine and handled by the cooling system.

### 2.6 Calculation of Thermal Efficiency of Machinery

The calculation of the thermal efficiency of the engine is carried out to find out how effectively the chemical energy of the fuel is converted into mechanical energy on the engine shaft. Thermal efficiency is an important parameter in the performance evaluation of a deep combustion engine, as it reflects the quality of the combustion process as well as the effect of the thermal conditions of the engine on overall performance.

Thermal efficiency is calculated based on the ratio between the engine output power and the fuel energy that comes in during the combustion process. The equations used in the calculation of thermal efficiency are expressed as follows:

$$\eta_{th} = P_{out} / (\dot{m}_f \times LHV)$$

where:

| | |
|---|---|
| $\eta_{th}$ | is the thermal efficiency of the engine, |
| $P_{out}$ | is the output power of the engine (W), |
| $\dot{m}_f$ | is the mass flow rate of the fuel (kg/s), |
| $LHV$ | is the value of the fuel under heat (kJ/kg). |

The value of engine output power is obtained from testing using a dynamometer, while the flow rate of fuel mass is obtained from the results of fuel consumption measurements in the previous sub-chapter. The calorific value of the fuel is determined based on the standard specifications of the fuel used during the test. Thermal efficiency calculations are performed on each variation of engine rotation to determine efficiency changes due to differences in thermal conditions and engine workload [6].

The results of the thermal efficiency calculation are then analyzed to see the relationship with the stability of the engine temperature maintained by the liquid cooling system. Higher efficiency in stable temperature conditions indicates that the cooling system has an important role in supporting a more optimal combustion process.

### 2.7 Data Analysis Techniques

Data analysis techniques are carried out to process and Interpret all data obtained from testing engine temperature, fuel consumption, heat transfer rate, and thermal efficiency. The measurement data obtained from each variation of engine rotation is first compiled in the form of a table to facilitate the processing process and comparison between operating conditions.

Simple statistical analysis is used to obtain the average values of each test parameter, such as cylinder head temperature, radiator inlet and outlet coolant temperature, fuel consumption, and thermal efficiency. The calculation of the average value is carried out to reduce the influence of data fluctuations due to changes in environmental conditions and uncertainty of the measuring instrument. In addition, data tendency analysis is carried out by comparing test results at each engine rev level.

To clarify the relationship between variables, the processed data is presented in the form of a graph. A graph of the relationship between engine rotation and temperature was used to evaluate the stability of the liquid cooling system, while a graph of the relationship between engine rotation and heat transfer rate and thermal efficiency was used to assess the performance of the cooling system against the combustion process. The presentation of the graph aims to make it easier to interpret data trends and support visual discussions.

The results of the data analysis are further discussed in the *RESULT* and *DISCUSSION sections* to explain the relationship between the performance of the liquid cooling system, engine temperature stability, and thermal efficiency of the Honda Vario 125. This analysis approach is expected to provide a comprehensive technical overview of the performance of the cooling system under different operating conditions.

## 3.0 RESULT

### 3.1 Engine and Coolant Temperature Measurement Results

This sub-chapter presents the results of the measurement of engine temperature and coolant on the Honda Vario 125 motorcycle at various variations of engine rotation. Measurements are made at three main points, namely the cylinder head, radiator inlet (inlet), and radiator outlet (outlet). This temperature data is used to evaluate the thermal stability of the engine as well as the effectiveness of the liquid cooling system in dissipating the heat generated during the combustion process.

The test results show that the cylinder head temperature increases as the engine revs increase. However, the temperature rise is still within a controlled range, which indicates that the liquid cooling system is working effectively. The coolant temperature at the radiator inlet is always higher than the temperature at the radiator outlet, which indicates the process of heat release through the radiator.

Table 1: Engine and coolant temperature data

| Engine Speed (rpm) | Temperature Head (°C) | Temperature Coolant Inlet (°C) | Temperature Coolant Outlet (°C) |
|---|---|---|---|
| 300 | 72 | 65 | 60 |
| 500 | 83 | 75 | 70 |
| 700 | 89 | 82 | 76 |
| 800 | 94 | 88 | 81 |

Based on Table 1, the temperature difference between the coolant inlet and outlet tends to increase at higher engine speeds. This shows that the amount of heat absorbed by the coolant and released through the radiator increases as the thermal load of the engine increases.

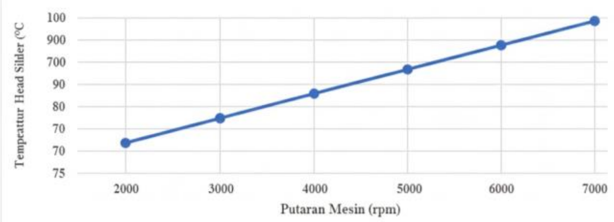


**Figure 1.** Graph of Relationship of Machine Rotation to Cylinder Head Temperature

This figure shows the relationship between engine rotation and cylinder head temperature. It can be seen that there is a relatively linear trend of temperature increase as the engine revs increase. However, there was no significant temperature spike, indicating that the liquid cooling system was able to maintain the stability of engine temperatures under various operating conditions.

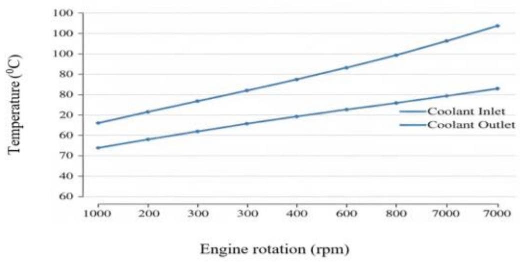


Figure 2: Inlet and outlet coolant temperature comparison chart

This graph shows the difference in coolant temperature before and after passing through the radiator. A consistent temperature difference indicates that the radiator is functioning effectively in dissipating heat from the coolant into the environment.

### 3.2 Results of Calculation of Heat Transfer Rate of Cooling System

This sub-chapter presents the results of the calculation of the heat transfer rate in the liquid cooling system of the Honda Vario 125 motorcycle. The calculation is carried out based on Coolant temperature data obtained in previous tests, namely the temperature of the coolant entering and exiting the radiator. The heat transfer rate describes the radiator's ability to dissipate heat from the engine into the environment and is a key indicator of the effectiveness of the cooling system.

The calculation results show that the value of the heat

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transfer rate increases as the engine revs increase. This increase occurs due to the increasing thermal load of the engine at high revs, so the amount of heat that must be released by the cooling system also increases. However, the liquid cooling system is still able to handle the increase in heat load stably.

Table 2: Coolant temperature difference (ΔT)

| Engine Speed (rpm) | T_in (°C) | T_out (°C) | ΔT Coolant (°C) | $\dot{Q}$ (W) |
|---|---|---|---|---|
| 3000 | 65 | 60 | 5 | 820 |
| 5000 | 75 | 70 | 5 | 1.150 |
| 7000 | 82 | 76 | 6 | 1.480 |
| 8000 | 88 | 81 | 7 | 1.720 |

Based on Table 2, the coolant temperature difference (ΔT) tends to increase at higher engine speeds. This indicates that the cooling system must dissipate a greater amount of heat as the engine's working intensity increases.

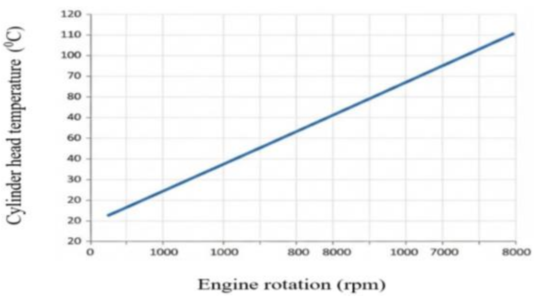


Figure 3: Graph of the relationship of machine rotation to heat transfer rate

This graph shows the relationship between engine rotation and the heat transfer rate of the cooling system. There is a relatively linear upward trend, which shows that the radiator is able to respond well to increased thermal loads. No indication of a decrease in cooling performance at high revs was found, which indicates that the capacity of the liquid cooling system is still sufficient.

### 3.3 Results of Fuel Consumption and Thermal Efficiency Measurements

This sub-chapter presents the results of fuel consumption measurements and calculations of the thermal efficiency of the Honda Vario 125 engine at various variations of engine rotation. This data is used to evaluate the relationship between the stability of engine temperatures maintained by the liquid cooling system and combustion performance and fuel energy utilization.

The test results show that the rate of fuel consumption increases as the engine revs increase. This increase is due to the greater energy requirement to maintain engine work at high revs. However, the increase in fuel consumption is offset by an increase in engine output, so thermal efficiency tends to increase to medium revs and is relatively stable at high revs.

Table 3: Thermal efficiency

| Engine Speed (rpm) | Fuel Mass Flow Rate, ṁ_f (kg/s) | Output Power, P_out (W) | Thermal Efficiency, η_th (% |
|---|---|---|---|
| 3000 | 0,00042 | 2.100 | 21,5 |
| 5000 | 0,00055 | 3.800 | 24,8 |
| 7000 | 0,00070 | 5.600 | 26,3 |
| 8000 | 0,00082 | 6.400 | 25,9 |

Based on Table 3, thermal efficiency has increased significantly from low to medium revolution. At high revs, thermal efficiency tends to be stable and slightly decreases, which can be attributed to increased heat losses and mechanical friction at those operating conditions.

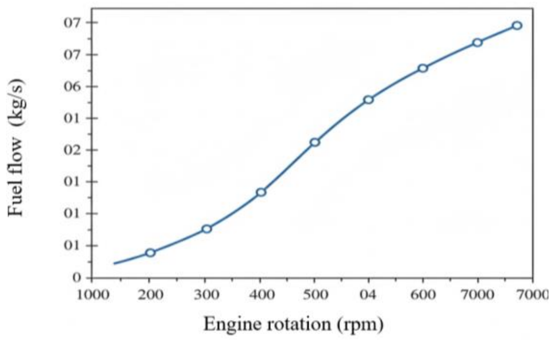


Figure 4: Graph of the relationship of engine rotation to fuel consumption

This graph shows the relationship between engine rotation and fuel flow rate. It is seen that fuel consumption increases progressively as the engine revs increase, which reflects the increasing energy requirements to maintain engine work.

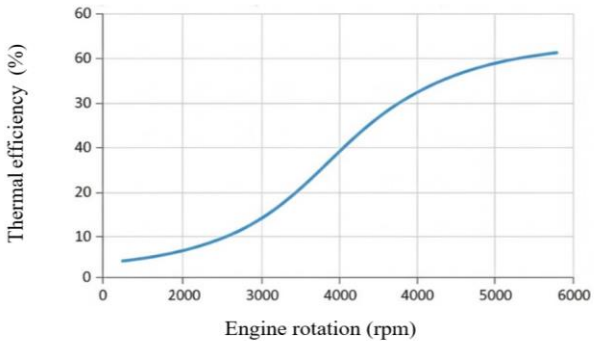


Figure **5**: Graph of the relationship of machine rotation to thermal efficiency

This graph shows the change in the thermal efficiency of the engine at each rotation variation. Efficiency increases at intermediate revs and tends to be stable at high revs, which suggests that the stability of engine temperatures contributes to a more optimal combustion process.

## 4.0 DISCUSSION

This discussion section discusses the relationship between engine temperature test results, heat transfer rate, fuel consumption, and thermal efficiency on the Honda Vario 125 motorcycle. The discussion is focused on the scientific interpretation of the data presented in Chapter 3.0, so as to explain the role of the liquid cooling system on the overall thermal performance of the engine [7].

The results of the engine temperature measurement showed that the increase in engine rotation caused an increase in the cylinder head temperature. However, the increase is still within safe working limits. This condition indicates that the liquid cooling system is able to maintain the stability of engine temperatures even when the thermal load increases. The relatively consistent temperature difference between the coolant inlets and outlets indicates that the heat discharge process takes place effectively at all variations of engine rotation [8].

The increase in heat transfer rate as the engine revs increases, indicating that the radiator and coolant circulation system are working responsively to the increase in heat generated by the engine. The absence of a decrease in the value of the heat transfer rate at high rotation indicates that the cooling system capacity is still sufficient and does not experience thermal saturation. This is especially important in daily vehicle use, especially in heavy traffic conditions or medium-distance travel [9].

In terms of fuel consumption, an increase in the rate of fuel flow at high revs is a common characteristic of internal combustion engines. However, the results of the thermal efficiency calculation show that efficiency increases at medium revs and tends to be stable at high revs. This phenomenon shows that the stability of engine temperatures maintained by the liquid cooling system contributes to a more optimal combustion process. Stable working temperature allows fuel evaporation and combustion to take place more perfectly, resulting in fuel energy can be used more effectively [10].

Overall, the results of this study confirm that the liquid cooling system in the Honda Vario 125 has an important role in maintaining the thermal balance of the engine. The good performance of the cooling system not only prevents overheating, but also supports thermal efficiency and engine performance under varied operating conditions.

## 5.0 CONCLUSION

This study has evaluated the performance of the liquid cooling system on the Honda Vario 125 motorcycle through testing the engine temperature, calculation of heat transfer rate, fuel consumption, and thermal efficiency at various variations of engine rotation. Based on the test results, the liquid cooling system is able to maintain the stability of the cylinder head temperature and coolant temperature despite the increase in thermal load as the engine revs increase.

The results of the heat transfer rate calculation show that the radiator's ability to dissipate heat increases consistently at higher engine speeds. This indicates that the cooling system has adequate capacity and works responsive to the increased heat generated by the engine. This stable cooling performance plays an important role in preventing overheating during operation.

In terms of fuel consumption and thermal efficiency, it is obtained that the thermal efficiency of the engine increases at medium revs and tends to be stable at high revs. This condition shows that the stability of engine temperatures maintained by the liquid cooling system supports a more optimal combustion process.

The results of this study are expected to be a technical reference in the development and evaluation of motor vehicle cooling systems, especially on automatic scooters with liquid cooling technology.

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