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Comparison of the Temperature of a C223 Diesel Engine with and without a Thermostat at 1500 RPM

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A B S T R A C T

This study investigates the effect of thermostat installation on the operating temperature of a C223 diesel engine during the warm-up period, addressing the common practice of removing the thermostat despite its documented negative effects on engine performance. A quantitative experimental method with a comparative approach was employed, testing two cooling system configurations, with and without a thermostat, at a constant engine speed of 1500 rpm under idle conditions. Temperature was measured using an infrared thermometer at 2, 4, and 6 minutes after engine start-up, with each condition repeated three times. The results showed that the engine equipped with a thermostat reached higher average temperatures (48.8°C, 68.7°C, and 81.8°C at 2, 4, and 6 minutes, respectively) than the engine without a thermostat (39°C, 46°C, and 50.6°C), with the difference becoming more pronounced over time. It is concluded that the thermostat significantly improves the warm-up performance of the C223 diesel engine by regulating coolant circulation, and its maintenance according to manufacturer specifications is recommended to ensure optimal engine performance and combustion efficiency

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INTRODUCTION

Advances in automotive technology have driven the widespread use of diesel engines in commercial vehicles, heavy equipment, and the transportation sector due to their high fuel efficiency and durability. However, diesel engine performance is greatly influenced by the cooling system's ability to maintain the engine's operating temperature within an ideal range. The cooling system functions to maintain the engine temperature at an optimal level so that the combustion process can proceed efficiently and engine components operate according to their design specifications (Suryapradana & Halim, 2024). The ideal operating temperature for a diesel engine is in the range of 80–90°C, which allows for increased combustion efficiency, lower exhaust emissions, and reduces the risk of damage caused by temperatures that are too high or too low (Albert K. Arkoh et al., 2021; Feriyanto et al., 2022; Prasetyo, 2022)

The thermostat is one of the main components of the cooling system, functioning to regulate the circulation of coolant according to the engine temperature (Pamulang, 2019). When the engine temperature is still low, the thermostat closes the path to the radiator so that the coolant circulates only within the engine block to accelerate the warming-up process (Abd et al., 2024). Once the operating temperature is reached, the thermostat gradually opens, allowing the coolant to flow to the radiator to maintain a stable engine temperature (Hariyanto et al., 2022; Suryapradana & Halim, 2024). Through this mechanism, the thermostat plays a crucial role in maintaining the engine's thermal balance during operation.

In practice, many users and technicians still remove the thermostat to prevent overheating. However, various studies show that removing the thermostat actually has a negative impact on engine performance. Feriyanto et al., (2022) reported that engines without thermostats are unable to reach their ideal operating temperature within 10 minutes, whereas engines equipped with thermostats can reach it within 4–9 minutes, depending on engine speed. Research by Albert K. Arkoh et al., (2021) also shows that removing the thermostat increases fuel consumption by about 65% and increases exhaust emissions due to incomplete combustion. Additionally, Syamsuddin et al., (2025) found that engine temperatures without a thermostat tend to be lower and less stable, potentially reducing combustion efficiency.

The absence of a thermostat causes coolant to continuously circulate to the radiator as soon as the engine is started, resulting in a longer warm-up process and making it difficult for the engine temperature to reach optimal operating conditions (Destra Amni et al., 2014). As a result, fuel consumption increases, exhaust emissions rise, and the combustion process becomes less efficient (Albert K. Arkoh et al., 2021; Feriyanto et al., 2022). Furthermore, uncontrolled coolant circulation causes heat from combustion to be released more quickly into the radiator, thereby increasing the time required for the engine to reach operating temperature (Syamsuddin et al., 2025).

Various studies on the effect of thermostats on engine temperature have been conducted, but most of them have focused on gasoline engines or other types of diesel engines (Albert K. Arkoh et al., 2021; Feriyanto et al., 2022;

Suryapradana & Halim, 2024). To date, research specifically evaluating the temperature characteristics of the C223 diesel engine remains very limited. Furthermore, previous studies have generally focused on final operating temperatures, whereas analyses of temperature rise characteristics during the warm-up process at specific time intervals have not been widely reported. Therefore, this study provides empirical data on the temperature characteristics of the C223 diesel engine with and without a thermostat under constant engine speed conditions of 1500 rpm.

This study aims to compare the operating temperatures of the C223 diesel engine with and without a thermostat, as well as to analyze the rate of temperature rise during the engine warm-up process at 1500 rpm. The results of this study are expected to contribute to the scientific understanding of the thermal characteristics of the C223 diesel engine and serve as a reference for users and technicians in maintaining the cooling system to ensure optimal engine performance.

LITERATURE REVIEW

Diesel engines generate large amounts of thermal energy during the combustion process. Only about 30–40% of the fuel's chemical energy is converted into mechanical energy, while the remainder is released as heat through exhaust gases, the cooling system, and radiation; therefore, a cooling system is necessary to maintain the engine's operating temperature within safe and efficient limits (Heywood, 2018). In a water cooling system, heat from the combustion chamber is transferred through the engine block and cylinder head to the coolant, which then dissipates it into the environment via the radiator (Dietsche et al., 2019; Fathallah et al., 2025). The cooling system functions to maintain the diesel engine's operating temperature within the range of 80–90°C—the conditions under which combustion efficiency, lubricating oil viscosity, and thermal expansion of components are at their optimal levels (Dietsche et al., 2019). If the engine temperature is too low, combustion becomes incomplete, leading to increased fuel consumption and exhaust emissions; conversely, if the temperature is too high, it can cause overheating, accelerate lubricant degradation, increase thermal stress, and heighten the risk of engine component failure (Burke et al., 2010; Zacharewicz et al., 2024).

This temperature control is carried out by a thermostat that functions as an automatic valve based on the coolant temperature. The wax-pellet thermostat is the most widely used type in vehicles because it provides a stable response to temperature changes (Dietsche et al., 2019). When the engine is still cold, the thermostat closes the path to the radiator so that the coolant circulates only within the engine block (small circulation) to accelerate the engine's temperature rise (Heywood, 2018). When the coolant temperature reaches approximately 82–88°C, the wax element begins to expand, causing the valve to open gradually. The thermostat fully opens at a temperature of approximately 95–100°C, allowing the coolant to flow to the radiator (large circulation) to dissipate heat into the environment and maintain the engine's operating temperature (Dietsche et al., 2019; Heywood, 2018). This mechanism accelerates the warm-up process, reduces temperature fluctuations, and keeps the engine operating at the temperature specified by the manufacturer (Burke et al., 2010; Dietsche et al., 2019).

Temperature characteristics during the warm-up phase significantly affect diesel engine performance. During the warm-up phase, the engine temperature and lubricating oil viscosity have not yet reached optimal conditions, so friction between components is relatively higher than when operating temperature has been reached (Heywood, 2018). An engine temperature that is too low results in incomplete fuel atomization, leading to reduced combustion efficiency and increased emissions, whereas a temperature that is too high accelerates lubricating oil degradation and increases the risk of component damage due to thermal stress (Burke et al., 2010; Zacharewicz et al., 2024). Therefore, the rate of temperature rise toward operating temperature is a key indicator for evaluating the effectiveness of the cooling system and the performance of the thermostat in a diesel engine (Burke et al., 2010).

METHODOLOGY

This study employed a quantitative experimental method using a comparative approach to investigate the effect of thermostat installation on the operating temperature of a C223 diesel engine. Two experimental configurations were evaluated: a cooling system equipped with a thermostat and a cooling system without a thermostat. During the experiment, the engine was operated under identical conditions to ensure consistency. The controlled variables included engine speed, engine load, coolant type, ambient condition, and measurement location. All tests were conducted at a constant engine speed of 1500 rpm under idle conditions.

The experimental setup consisted of a C223 four-cylinder diesel engine (2238 cc) equipped with a standard water-cooling system. Engine temperature was measured using an infrared thermometer with a measurement range of −50°C to 550°C and an accuracy of ±1°C. Engine speed was monitored using a digital tachometer with an accuracy of ±1 rpm, while a digital stopwatch with an accuracy of ±0.01 s was used to control the observation intervals. The cooling system employed a standard thermostat with an opening temperature of 82°C and standard engine coolant. Prior to the experiment, the measuring instruments were calibrated according to the manufacturer's specifications to ensure measurement accuracy.

Data collection was carried out under two experimental conditions. In the first condition, the engine was tested with the thermostat installed, while in the second condition the thermostat was removed and the thermostat housing was reinstalled to maintain a sealed cooling system. Before each test, the engine was allowed to cool until its initial temperature was approximately equal to the ambient temperature, and the coolant level was adjusted to the same level for every experiment. The engine was then started and maintained at a constant speed of 1500 rpm. Temperature measurements were recorded at 2, 4, and 6 minutes after engine start-up using an infrared thermometer directed at the engine water outlet, which is the coolant outlet located on the cylinder head before the coolant flows into the thermostat housing and radiator. This measurement point was selected because it represents the coolant temperature immediately after absorbing heat from the engine, providing a representative indication of the engine thermal condition. Each experimental condition was repeated three times, resulting in a total of 18 temperature measurements.

The collected data were organized according to the testing condition, observation time, and repetition number. Descriptive statistical analysis was employed to summarize the experimental data and identify the temperature characteristics under each testing condition. The experimental results were presented in tables and line graphs to illustrate the variation of engine temperature during the warm-up period and to facilitate the interpretation of the engine thermal behavior under different thermostat configurations.

RESULTS

Engine temperature measurements were conducted under two cooling system configurations, namely without a thermostat and with a thermostat, while maintaining a constant engine speed of 1500 rpm under idle conditions. Temperature was recorded at 2, 4, and 6 minutes after engine start-up. Each experimental condition was repeated three times, and the average values are presented in Table 1.

Table 1. Average Engine Temperature of the C223 Diesel Engine at 1500 rpm

Minute	Average Without Thermostat (°C)	Average With Thermostat (°C)
2	39	48,8
4	46	68,7
6	50,6	81,8

As summarized in Table 1, the engine temperature increased throughout the observation period under both cooling system configurations. However, the engine equipped with a thermostat consistently exhibited higher temperatures than the engine operating without a thermostat. The comparison of engine temperature under both experimental conditions is illustrated in Figure 1.

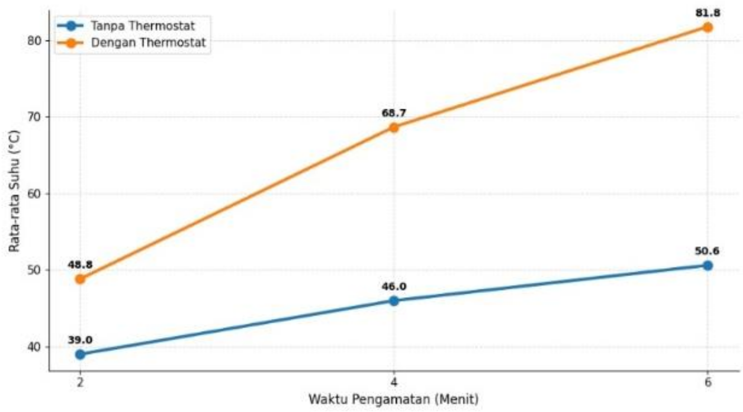

Figure 1. Comparison of Engine Temperature of the C223 Diesel Engine with and without a Thermostat at 1500 rpm

Figure 1 shows that both configurations exhibited a similar increasing temperature trend during the warm-up period. Nevertheless, the temperature profile of the engine equipped with a thermostat remained consistently higher than that of the engine without a thermostat throughout the experiment. In addition, the difference between the two temperature profiles became more pronounced as the observation time increased.

DISCUSSION

The results indicate that the installation of a thermostat improves the thermal performance of the C223 diesel engine during the warm-up period. The engine equipped with a thermostat reached its operating temperature more quickly than the engine without a thermostat. This behavior is consistent with the function of the thermostat, which regulates coolant circulation to accelerate engine warm-up while maintaining the operating temperature within the recommended range (Abd et al., 2024; Suryapradana & Halim, 2024).

In contrast, the engine operating without a thermostat exhibited a slower temperature increase because coolant continuously circulated through the radiator from the beginning of engine operation. As a result, heat generated during combustion was dissipated more rapidly, delaying the engine from reaching its normal operating temperature. Similar findings were reported by Feriyanto et al., (2022) and Syamsuddin et al., (2025), who found that removing the thermostat causes lower and less stable engine temperatures.

These findings also support previous studies that highlight the importance of maintaining proper engine operating temperature for combustion efficiency and engine reliability. Albert K. Arkoh et al., (2021) reported that operating an engine without a thermostat increases fuel consumption and exhaust emissions, while Hariyanto et al., (2022) demonstrated that a thermostat contributes to more stable engine temperature and reduces thermal stress on engine components.

The present study extends previous research by evaluating the thermal characteristics of a C223 diesel engine operating at a constant speed of 1500 rpm. The results provide additional experimental evidence regarding the role of the thermostat in improving engine warm-up performance and may serve as a practical reference for the maintenance of diesel engine cooling systems.

CONCLUSIONS AND RECOMMENDATIONS

This study compared the operating temperature of a C223 diesel engine with and without a thermostat at a constant engine speed of 1500 rpm. The experimental results demonstrate that the use of a thermostat enables the engine to reach its operating temperature more effectively than the engine operating without a thermostat. The thermostat regulates coolant circulation during the warm-up process, allowing the engine to achieve a more appropriate thermal condition for operation. These findings confirm the important role of the thermostat in maintaining the thermal performance of the C223 diesel engine.

The results of this study suggest that the thermostat should be maintained in accordance with the manufacturer's specifications to ensure proper engine warm-up and stable operating temperature. Future studies are recommended to evaluate the effect of thermostat installation under different engine speeds and loading conditions, as well as to investigate its influence on fuel consumption, exhaust emissions, and overall engine performance.

FURTHER STUDY

This study has several limitations. First, the experiment was conducted only at a constant engine speed of 1500 rpm under idle conditions, so the results may differ under varying engine speeds and loading conditions. Second, the evaluation focused only on engine temperature during the warm-up period without considering other performance parameters such as fuel consumption, exhaust emissions, coolant flow rate, or engine efficiency. In addition, the experiment was performed using a single diesel engine model (C223), which may limit the generalization of the findings to other engine types. Therefore, future studies are recommended to investigate the effect of thermostat installation under different operating conditions, engine loads, and engine speeds, as well as to evaluate its relationship with fuel economy, emission characteristics, and overall engine performance.

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REFERENCES

Abd, M., Zulfadli, T., Yusuf, M., Kamarullah, K., Mulkan, A., Safrizal, S., Azmal, A., & Zulfan, Z. (2024). ANALISIS PERUBAHAN SUHU PADA SISTEM PENDINGIN RADIATOR MESIN TOYOTA COROLLA. *Jurnal Mekanova : Mekanikal, Inovasi Dan Teknologi*, *10*(2), 486. https://doi.org/10.35308/jmkn.v10i2.10682

Albert K. Arkoh, Esther B. Kyere, & Isaac Edunyah. (2021). Comparative analysis of engine running performance with and without thermostat. *International Journal of Science and Research Archive*, *4*(1), 047–053. https://doi.org/10.30574/ijsra.2021.4.1.0171

Burke, R D, Brace, C J, Hawley, J G, & Pegg, I. (2010). Review of the systems analysis of interactions between the thermal, lubricant, and combustion processes of diesel engines. *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering*, *224*(5), 681–704. https://doi.org/10.1243/09544070JAUTO1301

Destra Amni, O., Amin, B., & Jurusan Teknik Otomotif Jln Hamka Air Tawar, Mp. (2014). *PENGARUH PELEPASAN THERMOSTAT TERHADAP KONSUMSI BAHAN BAKAR PADA MESIN TOYOTA KIJANG 5K*.

Fathallah, A. Z. M., Busse, W., & Clausthaldi, F. R. (2025). Fluid Flow Analysis of Jacket Cooling System for Marine Diesel Engine 93 KW. *International*

Journal of Marine Engineering Innovation and Research, *1*(2), 39–45. https://doi.org/10.12962/j25481479.v1i2

Feriyanto, D., Alva, S., Vikaliana, R., & Kristanto, A. S. (2022). ANALISIS SISTEM PENDINGIN MENGGUNAKAN THERMOSTAT DAN TANPA THERMOSTAT DALAM PENCAPAIAN PANAS MESIN PADA ALAT UJI PRESTASI. *Jurnal Rekayasa Mesin*, *13*(3), 637–646. https://doi.org/10.21776/jrm.v13i3.757

Hariyanto, A., Pengajar, S., Mesin, J. T., Madi, A., Laboratorium, P., Arbain, P. M., Perawatan, M. P., Perbaikan, D., Politeknik, M., & Samarinda, N. (2022). PENGARUH PENGGUNAAN JENIS COOLANT STANDARD DAN COOLANT PRESTONE PADA SISTEM PENDINGIN TERHADAP TEMPERATURE ENGINE TOYOTA INNOVA DIESEL 2.4 G A/T 2017 2.2L 2012. *Agus Hariyanto, MeKanik*, *15*(2).

Heywood. (2018). *I nternal Combustion Engine Fundamentals*.

Dietsche, Prof. Dr.-Ing. Konrad Reif, approx. 280 authors from industry, & the university and college sector. (2019). *Alphabets and numbers * Automotive Handbook 11th Edition*.

Pamulang, U. (2019). ANALISIS VARIASI JUMLAH SUDU DAN CAIRAN PENDINGIN (COOLANT) PADA KINERJA MESIN TERHADAP EFISIENSI BAHAN BAKAR DAN PENCEGAHAN TERJADINYA OVERHEATING. In *Jurnal Ilmiah TEKNOBIZ* (Vol. 8, Number 1).

Prasetyo, D. (2022). TEMPERATURE EXHAUST GAS ANALYSIS ON THE SHIP ENGINE. *Jurnal Rekayasa Mesin*, *13*(3), 629–635. https://doi.org/10.21776/jrm.v13i3.752

Suryapradana, I., & Halim, A. (2024). Analysis of Application of the Thermostat in the Cooling System of the Nissan CWB 45 Dump Truck Engine. *Sebatik*, *28*(2), 313–319. https://doi.org/10.46984/sebatik.v28i2.2496

Syamsuddin, U., Razi, M., Halik, A., Studi Perawatan, P., Mesin, P., Teknik Mesin, J., Negeri Samarinda, P., & Studi Teknik Alat Berat, P. (2025). Pengaruh Pelepasan Termostat Terhadap Temperatur Mesin. *Jurnal Teknologi MEDIA PERSPEKTIF*, *17*(1), 1–05. http://e-journal.polnes.ac.id/index.php/mediaperspektif/index

Zacharewicz, M., Zadrąg, R., Bogdanowicz, A., Socik, P., Wirkowski, P., & Hołownia, J. (2024). Evaluation of the impact of the thermal state of a diesel engine on its efficiency. *Combustion Engines*, *196*(1), 30–36. https://doi.org/10.19206/CE-170793