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The Effect of Water Flow Rate on the Effectiveness of the Mitsubishi Fuso 6D Engine Radiator

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INTISARI

Penelitian ini bertujuan untuk menganalisis pengaruh debit aliran air terhadap efektivitas pendinginan radiator menggunakan mesin MITSUBISHI FUSO 6D14. Data dikumpulkan pada variasi putaran mesin (1000–3000 rpm) dan debit aliran air (0.011–0.033 m³/menit). Proses pengukuran dilakukan menggunakan Radiator Tester dengan suhu awal 60°C dan suhu acuan 70°C hingga 75°C. Hasil penelitian menunjukkan bahwa semakin tinggi putaran mesin, semakin besar debit aliran air, sehingga meningkatkan efektivitas pendinginan radiator. Penyerapan kalor terjadi lebih maksimal pada aliran turbulen dibandingkan laminar, mempercepat perpindahan panas antara fluida dan dinding pipa. Efektivitas radiator meningkat signifikan pada lima menit pertama dan cenderung stabil setelah 30 menit penahanan waktu. Penelitian ini memiliki keterbatasan, seperti fokus pada mesin MITSUBISHI FUSO 6D14 tanpa beban, suhu kerja maksimal 93°C, serta parameter tertentu yang tidak diperhitungkan. Meskipun demikian, penelitian ini memberikan wawasan penting dalam optimasi sistem pendinginan radiator kendaraan.

Kata Kunci: Debit Aliran Air, Efektivitas Pendingin, Radiator, Mitsubishi Fuso, Aliran Turbulen.

ABSTRACT

This study aims to analyze the effect of water flow rate on the cooling effectiveness of a radiator using the MITSUBISHI FUSO 6D14 engine. Data were collected at various engine speeds (1000–3000 rpm) and water flow rates (0.011–0.033 m³/min).

Measurements were conducted using a Radiator Tester with an initial temperature of 60°C and a reference temperature ranging from 70°C to 75°C. The results indicate that higher engine speeds lead to greater water flow rates, thereby enhancing the radiator's cooling effectiveness. Heat absorption is more optimal in turbulent flow compared to laminar flow, accelerating heat transfer between the fluid and pipe walls. Radiator effectiveness showed a significant increase within the first five minutes and tended to stabilize after 30 minutes of holding time. This study has limitations, such as focusing only on the MITSUBISHI FUSO 6D14 engine without load, a maximum operating temperature of 93°C, and certain parameters that were not considered. Nevertheless, this research provides valuable insights for optimizing vehicle radiator cooling systems.

Keywords: *Water flow rate, cooling effectiveness, radiator, Mitsubishi Fuso, turbulent flow.*

1. INTRODUCTION

The advancement of automotive technology is progressing rapidly, driven by societal trends and user demands for multifunctional, environmentally friendly, recyclable, and durable engines. Automotive manufacturers strive to meet these demands through product innovation. An engine is an integrated system consisting of various subsystems, such as electrical systems, fuel systems, lubrication systems, and cooling systems. Although not primary systems, lubrication and cooling systems play a vital role in protecting the engine and maintaining its long-term performance.

The lubrication and cooling systems are critical supporting components in an engine. The lubrication system prevents wear caused by friction on the engine's moving parts, thereby maintaining performance and extending the engine's lifespan. The cooling system, whether air- or water-based, functions to absorb heat from the combustion of fuel to prevent overheating, which can damage the mechanical properties and structure of engine components. In an aircooling system, heat is dissipated through cooling fins that transfer the heat to the surrounding air. In a watercooling system, heat is absorbed by circulating water and cooled via the radiator with the help of a blower. The effectiveness of a watercooling system is influenced by the flow rate of the circulating water and the speed of air hitting the radiator.

This study aims to analyze the effect of water flow rate on the cooling efficiency of a radiator using a Radiator Tester. This tool is designed to measure relevant parameters and can be applied to various types of engines, whether on engine stands or in vehicles. The research focuses on the relationship between water flow rate and the efficiency of the radiator cooling system.

An internal combustion engine is a heat engine where the temperature of the gases in the combustion chamber can reach up to 2500°C during operation. The metal materials around the combustion chamber can reach temperatures of approximately 600°C. Therefore, a cooling system is essential. The cooling system in vehicle engines functions to maintain the engine temperature in an ideal condition. Both internal and external combustion engines perform combustion processes to generate energy, which is then converted into mechanical power through the engine mechanism(Astriawati & Wibowo, 2020).

The known methods of engine cooling are the aircooling system and the watercooling system. Both methods can dissipate about 33% of the engine's heat to the atmosphere (outside air) through convection, where air is directed to the surface of the heated metal material. However, engine efficiency decreases as heat transfer increases. Air cooling is used when the heat from a working or rotating engine is transferred to the outside air through fins. In the watercooling system, heat is transferred to the water surrounding the combustion chamber and cylinder. The heated water then circulates to the radiator. The water flows through the radiator pipes, and its heat is transferred to the radiator fins, where it is released into the air. The cooled water is then returned to the engine (Daryanto, 2019).

A radiator is a component that functions to temporarily hold the coolant and serves as a medium to release heat from the engine to the outside air with the help of a fan while the engine is running. The type of radiator used in each unit varies depending on its placement and position according to its construction. When the fan drive uses a V-belt, the radiator is installed at the front of the engine. If the fan drive uses a hydraulic or electric motor, the radiator can be placed anywhere, depending on the unit's design (Nusur, 2019).

Heat transfer is the process of energy moving from one place to another due to a temperature difference between the two locations. **Conduction** is the transfer of heat from one area to another without involving the movement of particles of the material. Conduction does not always transfer heat. For example, even though electricity has a high temperature, conduction does not necessarily relate to heat, as electricity can also transfer through conduction. **Convection** is a type of heat transfer commonly occurring in flowing fluids, such as gases and liquids. This process occurs due to differences in the fluid's density itself (Fathan Mubina Dewadi, S.T, M.T et al., 2022).

teknologi otomotif berkembang pesat, dipicu oleh tren masyarakat dan tuntutan pengguna akan mesin yang multifungsi, ramah lingkungan, dapat didaur ulang, dan tahan lama. Produsen otomotif berupaya memenuhi tuntutan ini dengan inovasi produk. Mesin merupakan sistem terintegrasi yang terdiri dari berbagai subsistem, seperti kelistrikan, bahan bakar, pelumasan, dan pendinginan. Meskipun bukan sistem utama, pelumasan dan pendinginan memiliki peran vital dalam melindungi mesin dan mempertahankan kinerjanya dalam jangka panjang.

2. RESEARCH METHODS

This study employs an experimental method with a One Shot Model approach to collect data in a single instance on the MITSUBISHI FUSO 6D14 engine. The research variables include: the dependent variable, radiator effectiveness; the independent variables, water flow rate (0.011–0.033 m^3/min) and water temperature before entering the engine; and the control variables, cooling fan rotation and air flow velocity. The study was conducted from November to December 2023 at PT Bukaka Teknik Utama.

The research procedure begins with a research simulator, namely a radiator tester, consisting of main components such as a radiator, flowmeter, fan, thermometer, anemometer, and electric motor. The second stage involves preparation, including inspection and adjustment of the equipment to match specifications, such as the ignition system, regulator, and flowmeter. The third stage is the implementation, where initial data collection and testing are carried out at various engine speeds (1000–3000 rpm) and water flow rates. All data are recorded in observation tables. The fourth stage involves experiments, where tests are conducted with five levels of water flow rates to analyze the relationship between water flow rate and radiator cooling effectiveness.

In this study, data are analyzed using an exploratory method and visualized in line graphs to facilitate interpretation of the phenomena observed.

3. RESULTS AND DISCUSSION

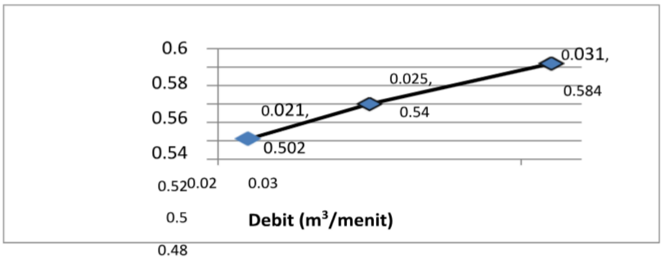
The research data were obtained from the results of experiments conducted. The engine used for data collection in this study was the MITSUBISHI FUSO 6D14 engine, and the experimental data were collected by measuring the temperatures operating on the radiator tester instrument.

Table 1. Experimental data at a water flow rate of 0.021 m³/min (1700 rpm rotation speed).

Periode							
2	0.033	30.6	70.0	52.0	30.5	50.645	0.51
3	0.033	30.6	72.0	54.0	30.0	50.58	0.49
4	0.899	30.6	75.0	54.5	30.0	52.50	0.50
5	0.899	30.6	76.0	55.5	31.0	53.50	0.50
6	0.899	30.6	78.0	56.1	31.0	54.97	0.51
7	0.899	30.6	74.2	54.36	32.76	52.439	0.502

Table 2. Processed Data Results

n	Q	$\mathcal{E}$
1700 rpm	0.021m^3/minute	0.502



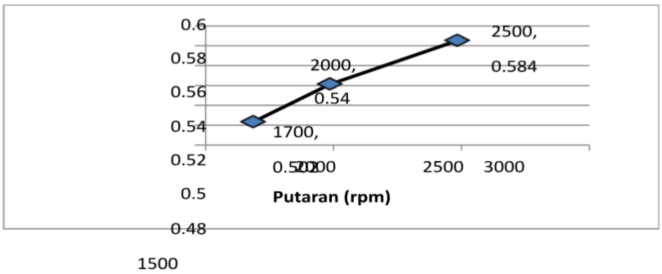


Figure 1. Graph of the effect of engine speed on radiator effectiveness.

The research data were collected at engine speeds of 1000–3000 rpm with variations in water flow rates of 0.011–0.033 m³/min. The data collection process was based on an initial temperature reference (Th1) of 60°C, and measurements were taken at a temperature of 70°C. However, for flow rates of 0.028–0.033 m³/min (engine speeds of 2500–3000 rpm), the reference temperature (Th1) was raised to 75°C because heat transfers more quickly at higher speeds.

Analysis of the relationship between engine speed and heat: As the engine speed increases, more heat is generated within the cylinder, which leads to an increase in water flow rate. A higher flow rate increases the amount of fluid circulating, thus absorbing more heat (cooling effect). The role of turbulent flow: Heat transfer inside the pipe is influenced by turbulent flow, which accelerates heat transfer compared to laminar flow. Increased turbulence reduces the thermal resistance of the laminar boundary layer, thereby enhancing the heat transfer coefficient.

Radiator cooling efficiency: Heat absorption occurs in the radiator, where hot water is cooled by air from the blower. A significant temperature difference (Th2–Th1) increases the radiator's effectiveness. At higher flow rates, the speed of water and air flow plays a crucial role in enhancing cooling efficiency.

Heat reduction trend: Observations were conducted for up to 30 minutes to monitor the cooling trend. The effectiveness value increased sharply during the first to fifth minutes due to a significant temperature difference between the outside air and the radiator water. After the fifth minute, the effectiveness value tended to stabilize as temperature increases became uniform across all parameters (Th1, Th2, Tc2).

4. CONCLUSION

Higher engine speeds increase the water flow rate, resulting in more effective cooling. The turbulent flow condition inside the pipe helps improve heat transfer, which enhances radiator cooling effectiveness. The radiator effectiveness tends to stabilize after five minutes of operation, reflecting the efficiency of the cooling system under continuous operating conditions.

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