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Analysis of The Effect of Fin Thickness Variations on The Decrease in Motorcycle Radiator Temperature Using Computational Fluid Dynamic

Mochamad Malik Abdullah Saripudin 1[a*], Reza Setiawan 2[a]

[a]*Department of Mechanical Engineering, Faculty of Engineering, University of Singaperbangsa Karawang,*
Jl. HS. Ronggo Waluyo Telukjambe Timur, Karawang 41361, Indonesia
**Corresponding author email: 2010631150045@student.unsika.ac.id*

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ABSTRACT

The radiator is an important component in a motorcycle cooling system that functions to control engine temperature. The design and thickness of the fins on the radiator play a key role in determining the efficiency of heat transfer and pressure drop in the system. This study analyzes the effect of variations in fin thickness (0.14 mm, 0.17 mm, and 0.19 mm) on radiator performance using the Computational Fluid Dynamics (CFD) method. Simulations were performed at air velocities of 16.7 m/s, 27.8 m/s, and 33.3 m/s, with ethylene glycol coolant at 373 K and ambient air at 300 K. The simulation results show that thinner fin thicknesses, such as 0.14 mm, are more effective in reducing the coolant outlet temperature, with the lowest temperature achieved being 306.091 K. However, thinner fins also produce higher air outlet temperatures. Conversely, a fin thickness of 0.19 mm shows lower heat transfer efficiency, indicated by a higher coolant outlet temperature. The 0.17 mm fin thickness provides the best balance between coolant temperature drop and air outlet temperature, making it the optimal choice for efficient radiator design. With the right radiator design, the efficiency of the cooling system can be improved, which in turn contributes to better engine performance and longer engine life.

Keywords: Radiator, Cooling system, Computational fluid dynamic, Heat Transfer

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1. Introduction

The cooling system is an important component in the performance of a motorcycle engine, which serves to control the engine temperature to stay within safe limits. With the increasing performance and speed of motorcycles, the need for a more efficient cooling system becomes crucial [1]. The radiator as one of the main elements in the cooling system plays an important role in the heat transfer process from the coolant to the outside air. One of the factors affecting radiator performance is the design and thickness of the fin used [2].

Previous studies have widely discussed the effect of fin design on radiator efficiency. Fin design optimization can significantly improve the thermal performance of motorcycle radiators [3]. This study highlights the role of fin shape in increasing the convective heat transfer coefficient, which leads to improved cooling performance. Other studies have also discussed how fin surface material and texture contribute to the heat exchange process, emphasizing the trade-off between increasing surface area and pressure drop [4]. These findings are in line with the understanding that wavy fins can increase airflow turbulence, which in turn can increase the heat transfer coefficient, making them a preferred choice for modern radiators.

Radiator fins are designed to increase the heat transfer surface area, which allows more heat to be released from the coolant. Wavy fins are chosen for their ability to increase airflow turbulence, which can increase the heat transfer coefficient [3]. However, fin thickness also plays an important role in determining the thermal efficiency and pressure drop in the system. Different fin thicknesses can result in different flow and heat transfer characteristics, ultimately affecting the overall performance of the radiator [4].

Variations in fin thickness have a direct impact on the contact surface area between the fin and the flowing fluid, be it air or coolant. Thinner thickness will increase the surface area and allow for more efficient heat transfer, but can also lead to increased pressure drop due to greater flow resistance [5]. On the other hand, greater fin thickness can reduce pressure drop but may not be as effective in heat transfer [6].

This study aims to analyze the effect of fin thickness variation on motorcycle radiator using Computational Fluid Dynamics (CFD) method. The fin thickness variations tested were 0.14 mm, 0.17 mm, and 0.19 mm [7]. The simulation was conducted at the average speed of motorcycle users on the highway, which is 60 km/h or 16.7 m/s using Ethylene Glycol coolant at 373 K and environmental air at 300 K. The purpose of this study is to determine the most efficient fin thickness in increasing heat transfer and reducing pressure [8].

2. Methodology of Research

In this research, the method used is Computational Fluid Dynamics (CFD) simulation to analyze the effect of fin thickness variation on the thermal performance of a motorcycle radiator. The simulation process begins with modeling the geometry of a radiator that uses a type of wavy fin with aluminum material for both fins and tubes. Radiator Model Design A 3D model of the wavy fin radiator was created using CAD software. The three fin thickness variations tested in this simulation are 0.14 mm, 0.17 mm, and 0.19 mm.

Figure 1. Geometri CAD Fin and Tube

Simulations were conducted with varying air velocities, namely 16.7 m/s, 27.8 m/s, and 33.3 m/s, which represent the motor speed conditions when driving on the highway. The cooling fluid used is ethylene glycol, with the cooling fluid inlet temperature set at 373 K and the ambient air inlet temperature at 300 K.

Table 1. Fin and Tube Specifications

No	Specifications	Details
1	Fin Type	Wavy Fin
2	Fin Material	Aluminium
3	Tube Material	Aluminium
4	Fin Thickness	0,14 mm
		0,17 mm
		0,19 mm
5	Air Velocity	16,7 m/s
		27,8 m/s
		33,3 m/s
6	Coolant Velocity	0,5 m/s
7	Coolant Type	Ethylene Glycol
8	Coolant Inlet Temperature	373 K
9	Air Inlet Temperature	300 K

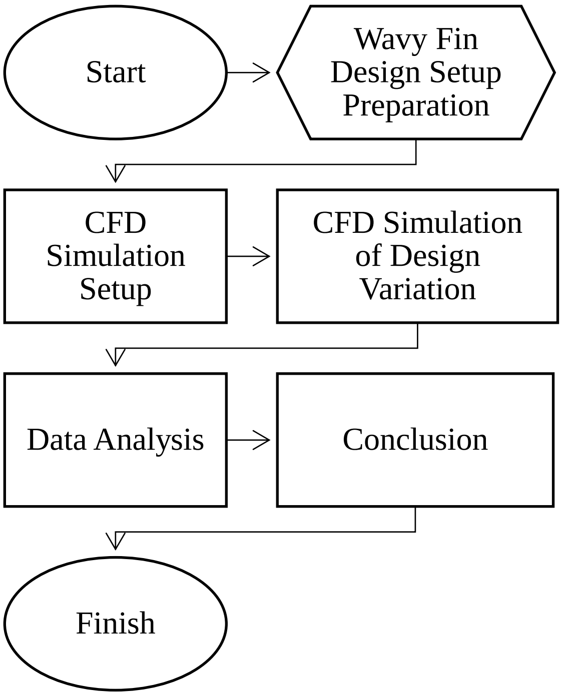

Figure 2. Research Flowchart

The steps in the simulation include geometry modeling, setting boundary conditions, and selecting an appropriate turbulence model for the flow of air and coolant inside the radiator. The simulation data is then analyzed to determine the outlet temperatures of the coolant and air at various fin thickness variations. The simulation results were used to evaluate the heat transfer efficiency as well as the temperature drop achieved by each fin thickness variation. This method allows the identification of the most optimal fin thickness to achieve the desired thermal performance in a motorcycle radiator.

3. Result and Discussion

In this study, CFD simulation was conducted to analyze the effect of fin thickness variation on motorcycle radiator on the outlet temperature of coolant and air. The fin thickness variations tested were 0.14 mm, 0.17 mm, and 0.19 mm using ethylene glycol coolant at an inlet temperature of 373 K and environmental air at an inlet temperature of 300 K. The air velocities used in the simulation were 16.7 m/s, 27.8 m/s, and 33.3 m/s [9].

Based on the results of Computational Fluid Dynamics simulations on radiators with variations in fin thickness, outlet temperature data for coolant and air fluids at various air velocities were obtained. For a fin thickness of 0.19 mm, the coolant outlet temperature ranges from 324.961 K to 327.255 K, while for air, the temperature ranges from 303.954 K to 304.149 K [10]. At a fin thickness of 0.17 mm, the coolant outlet temperature is in the range of 321. 381 K to 326.374 K, with the air temperature ranging from 302.324 K to 304.579 K. As for the fin thickness of 0.14 mm, the coolant outlet temperature ranges from 324.861 K to 327.345 K, and the air temperature is between 303.681 K to 304.55 K [11]. The simulation results at a thickness of 0.17 mm produce a good balance between reducing the temperature of the coolant and the air outlet, compared to thicknesses of 0.19 mm and 0.14 mm.

Table 2. Outlet Temperature Results Fin Thickness 0.19 mm

	0,19	
Air Velocity	Cooling	Air
16,7 m/s	324.961 [K]	303.954 [K]
27,8 m/s	326.787 [K]	304.149 [K]
33,3 m/s	327.255 [K]	303.956 [K]

Table 3. Outlet Temperature Results Fin Thickness 0.17 mm

	0,17	
Air Velocity	Cooling	Air
16,7 m/s	325.444 [K]	304.579 [K]
27,8 m/s	326.374 [K]	303.76 [K]
33,3 m/s	321.381 [K]	302.324 [K]

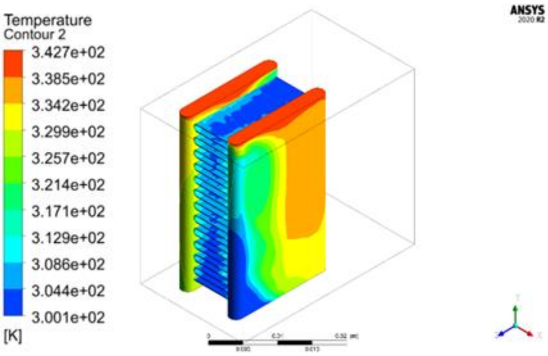

Figure 3. Results of 0.19 mm Fin Contour at 33.3 m/s Velocity

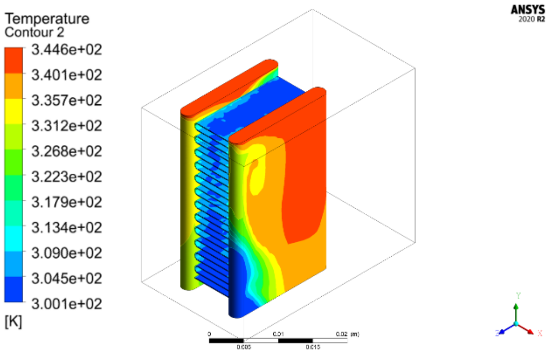

Figure 4. Results of 0.19 mm Fin Contour at 27.8 m/s Velocity

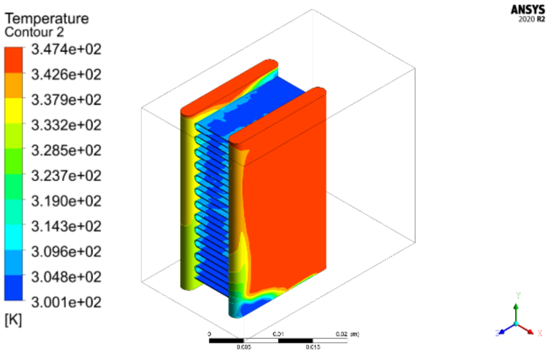

Figure 5. Results of 0.19 mm Fin Contour at 17.8 m/s Velocity

From the data obtained, it can be seen that the variation of fin thickness affects the outlet temperature distribution of the coolant and air fluids . Larger fin thicknesses, such as at 0.19 mm, show a slight increase in coolant outlet temperature as air velocity increases, which could be indicated as the effect of increased heat transfer due to increased air velocity improving forced convection at the fin surface [12]. However, this increase in temperature also indicates that the pressure drop may not be optimal, resulting in heat transfer not taking place as effectively as expected.

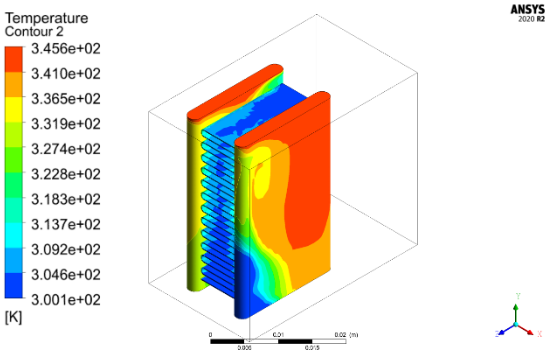

Figure 6. Results of 0.17 mm Fin Contour at 33,3 m/s Velocity

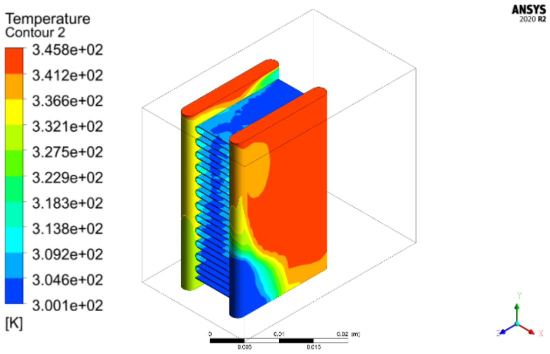

Figure 7. Results of 0.17 mm Fin Contour at 27,8 m/s Velocity

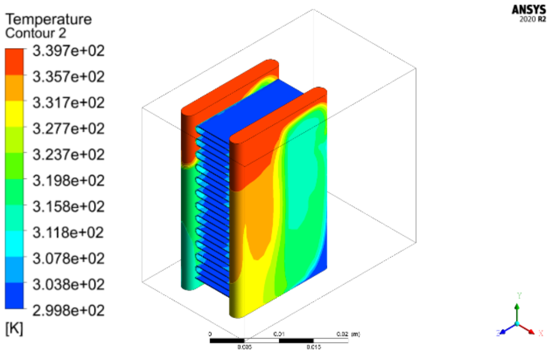

Figure 8. Results of 0.17 mm Fin Contour at 16,7 m/s Velocity

At a fin thickness of 0.17 mm, although there is a decrease in coolant outlet temperature at the highest air velocity (33.3 m/s), this value indicates that this fin thickness provides a balance between heat transfer and pressure drop [13]. This indicates that a fin thickness of 0.17 mm allows for more efficient airflow, which increases the cooling capacity without a significant increase in pressure drop.

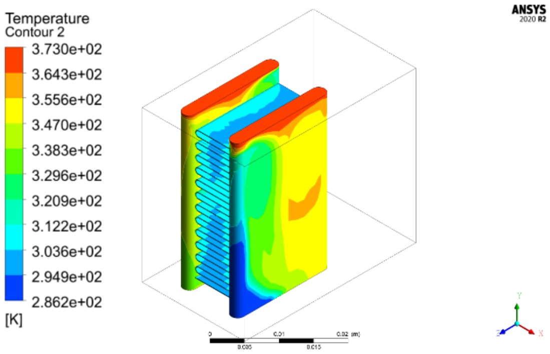

Figure 9. Results of 0.14 mm Fin Contour at 33,3 m/s Velocity

In contrast, at a fin thickness of 0.14 mm, although there was a significant increase in coolant outlet temperature with increasing air velocity, this increase was still in a similar range to the other fin thicknesses. This suggests that although the 0.14 mm fin thickness has a larger heat transfer surface area, the resulting increase in airflow resistance might affect the overall performance of the radiator [14].

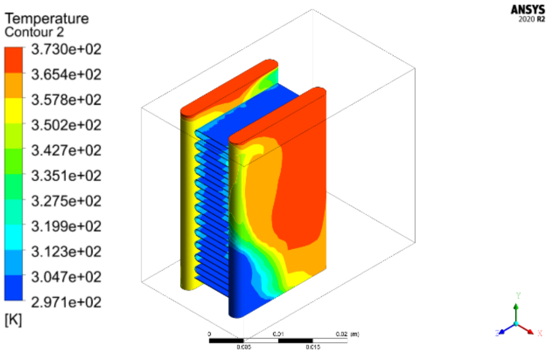

Figure 10. Results of 0.14 mm Fin Contour at 27,8 m/s Velocity

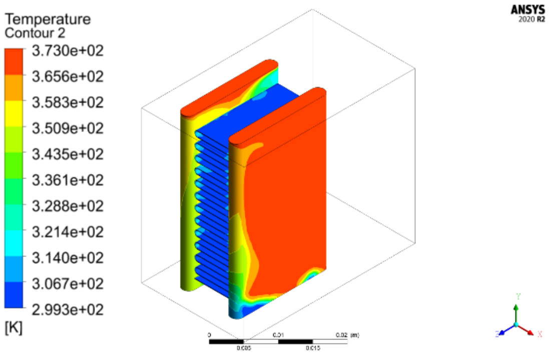

Figure 11. Results of 0.14 mm Fin Contour at 16,7 m/s Velocity

In general, these results show that a smaller fin thickness does not necessarily guarantee better thermal performance, as pressure drop also plays an important role in heat transfer efficiency [15]. A fin thickness of 0.17 mm seems to provide the best balance between heat transfer efficiency and pressure drop, making it the optimal choice in this study.

4. Conclusion

Based on the results of the research conducted, it can be concluded that variations in fin thickness on motorcycle radiators have a significant influence on heat transfer performance and pressure drop. The fin thickness of 0.17 mm shows the most optimal performance, with a good balance between heat transfer efficiency and pressure drop. This is indicated by the relatively lower and stable coolant outlet temperature distribution over a wide range of air velocities, indicating the ability of the fins to effectively improve heat transfer without compromising airflow.

In contrast, larger (0.19 mm) and smaller (0.14 mm) fin thicknesses showed greater variations in outlet temperature, indicating a potential increase in flow resistance and a decrease in heat transfer efficiency. Larger fin thicknesses tend to increase the coolant outlet temperature more significantly as the air velocity increases, indicating that pressure drop may be a limiting factor in heat transfer efficiency.

From these results, it is suggested that a fin thickness of 0.17 mm be considered as the optimal design for motorcycle radiators, as it provides the best combination of heat transfer efficiency and pressure drop minimization, which can ultimately improve overall cooling performance.

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