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Heat Transfer Simulation Study of Cooling Fin Units in Personal Computer Processors Using the Finite Element Method

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ABSTRACT

Everyone would want convenience in completing the work in his life, be it light work or heavy work that is high risk. As we all know, today's technology is so fast that it can replace human jobs where all human work wants to be completed with the results we want. Machines are one example of the application of technology that has a major role in our lives, where an energy, such as electrical energy is converted into motion energy that produces a business in its use. Machines are always evolving because the types of work that are increasingly diverse are always looking for new alternatives in an effort to make the job easier. Of the many types of construction conveyance or conveyor machinery is one End. While the lowest is the AMD parallel fin unit with copper material of 0.00417 K/mm. From the three histogram images above, it can be concluded that the circular fin type with 2024-T3 aluminum material has a better ability to conduct heat than other types of fins and materials. And the AMD parallel fin type with Copper Annealed material is not good at conducting heat. From the operation of the simulation program Visual Nastran 2004 that has been made, several conclusions can be drawn, namely: (1) Study of the performance of the fin unit in dissipating the heat of the processor on a personal computer (PC) operating in the temperature range of 298 – 303 K. The type of fin used for research these are: (a) AMD parallel fins. (b) Parallel fins. (c) Circular fin. (a) AMD parallel fins. (b) Parallel fins. (c) Circular fin. (a) AMD parallel fins. (b) Parallel fins. (c) Circular fin.

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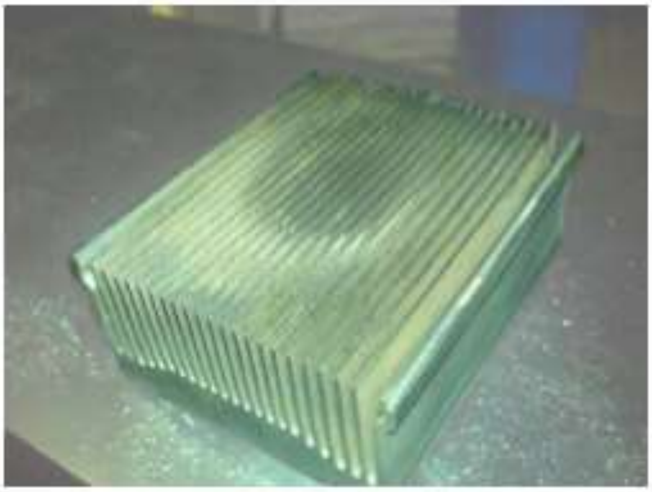
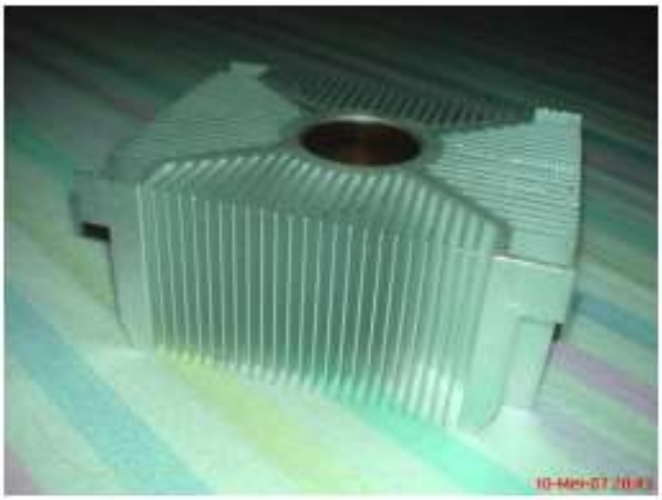
1. INTRODUCTION

The existence of computers has become an important requirement for today's industrial world (Indrajit, 2000). Almost all jobs in the industry are assisted by computer equipment with the aim of increasing productivity, producing better product quality, which is characterized by accuracy, precision and reliability. For this purpose, good computer performance is needed for data access and command execution as planned (Karim et al., 2005). However, such a computer performance will cause an increase in processor work which is higher and as a consequence results in a higher processor temperature (Wedjo, 2007). High temperatures on the processor are undesirable because they can damage the circuitry on the processor (Zaki, 2010). The higher the working capacity of the computer unit results in a significant temperature increase in the processor (Cahyati, 2018). The processor works optimally at temperatures below 50°C/323 K (www.intel.com). If the processor works above the specified working temperature, it will cause damage to the processor (Azizi, 2019). For that we need another equipment that is able to maintain heat stability (temperature) on the processor so that the processor temperature is at the working temperature limit or better at the optimal temperature (Angkasah, 2019). Generally auxiliary equipment used to maintain heat stability (temperature) (A'yun, 2013) on the processor is a fan and fins as a tool to channel or dissipate the heat generated on the processor. Specifically for fins, one of the fins used at this time is a parallel fin model and a circular fin model as shown in Figures 1.1 and 1.2 below (Rokhadi, 2010):



a) Sirip Pada Prosesor Intel



b) Sirip Pada Prosesor Amd

Figure 1. Processor Fins with Parallel Fin Model

Along with the development of processor technology, fin units with parallel arrangement as shown in Figure 1.1 are increasingly rarely used (Naim, 2021). The use of fins with circular grooves (Figure 1.2) is more widely used on computers that have higher performance (Tunak, n.d.).

Figure 2. Processor Fin With Circular Fin Model

The circular fin unit is a new innovation and for that it is necessary to study how the performance of the parallel fin unit and the circular fin (Figure 1.2) dissipate the heat that occurs in the computer, so that scientific evidence will be obtained why parallel fins are starting to be abandoned and switch to circular fins (Puspito, n.d.). For this purpose, research related to it is carried out and reported in this thesis.

The aims of this research are: (1) Study the performance of parallel and circular fin units in heat dissipation. (2) the processor on a personal computer (PC). (3) Calculating the temperature and its distribution when the processor is running at optimal temperature (Utami et al., 2017). (4) Comparing the appropriate fin material with the heat level that occurs when the computer operates at the optimal temperature based on the distribution of heat distribution on the fin geometry (Fahmi, 2021). (4) Determine the fin unit that has the best performance in dissipating the heat of the processor working at the optimal temperature. The benefits of this research are (Silfiyati, 2016): (1) Knowing how the fins work better to deal with the heat that occurs in personal computers (PCs) (Latifah, 2015). (2) Can choose the processor fin according to the needs. (3) Can overcome the damage caused by heat on the computer.

2. RESEARCH METHOD

1.1 Determination of Physical and Mechanical Properties of Materials

The workpiece used to make the fin is a material that has good heat conductivity. In this study, selected fins made of the following materials:

1.1.1 Aluminum 2024-T3

This material has the following parameters:

Table 1. Physical and Mechanical Properties of 2024-T3 . Aluminum Material
(Source: asm.matweb.com)

No	Physical Properties	Score
1	Modulus of Elasticity	7.31e+10 Pa
2	Position Ratio	0.33
3	Density	2.77e+3 kg/m3
4	Thermal Conductivity	190 W/mK
5	Yield Stress	3.45e+8 Pa
6	Ultimate Tensile Stress	4.83e+8 Pa
7	Specific Heat	962 Nm/(kg K)
8	Thermal Coef. Of Expansion	2.25e-5m/(m K)

1.1.2 Copper-Annealed

The physical and mechanical properties of the Cupper-Annealed material are as follows:

Table 2. Physical and Mechanical Properties of Cupper-Annealed Materials
(Source: http://www.efunda.com)

No	Physical Properties	Score
1	Modulus of Elasticity	1.17e+11Pa
2	Position Ratio	0.32
3	Density	8.9e+3kg/m3
4	Thermal Conductivity	393 W/mK
5	Yield Stress	7e+7Pa
6	Ultimate Tensile Stress	1.85e+8Pa
7	Specific Heat	385 Nm/(kg K)
8	Thermal Coef. Of Expansion	1.65e-5m/(m K)

3. RESULTS AND DISCUSSIONS

3.1 Defining the Type of Analysis

In this simulation, the calculation of the temperature/heat distribution is carried out. The step taken is to run the thermal command when executing the program as shown in the menu in Figure 4.1.

Figure 3. Analysis Type Dialog Box

The temperatures analyzed in this simulation are those obtained from measurements using the Smart Guardian software(Karim et al., 2005). From the measurement results, it can be seen that the processor operating temperature data increased significantly in the operating life span from 0 to 40 minutes(Martha et al., n.d.), and then increased gradually (slowly) from 301 K to 302 K in the time span from 40 to 80 minutes.(Lestario, 2018). Furthermore, the increase occurred again from 302 K to 303 K during the operating period from 80 minutes to 90(Yolanda, 2018). It no longer undergoes significant changes and for that, the operating temperature is used up to 90 minutes only(Chafid & Kusumawardhani, 2010), and the operating temperature is at 298-303 K (see Figure 4.2)

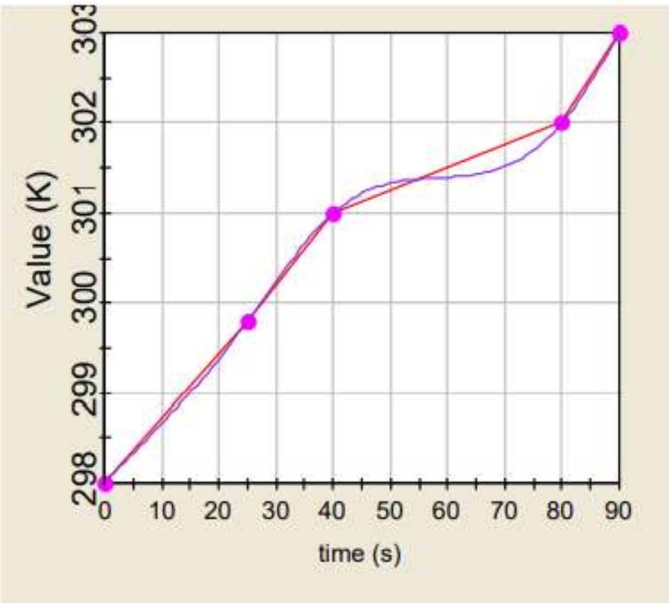


Figure 4. Increase in temperature when the computer is working

3.2 Cooling Occurs When The Fan Is Attached To The Fin Unit

Installed a fan as cooling, then the surface of the fin unit will flow air whose temperature is the same as the ambient temperature. The ambient temperature value recorded in the software is 29°C (302 K), see Figure 4.3.

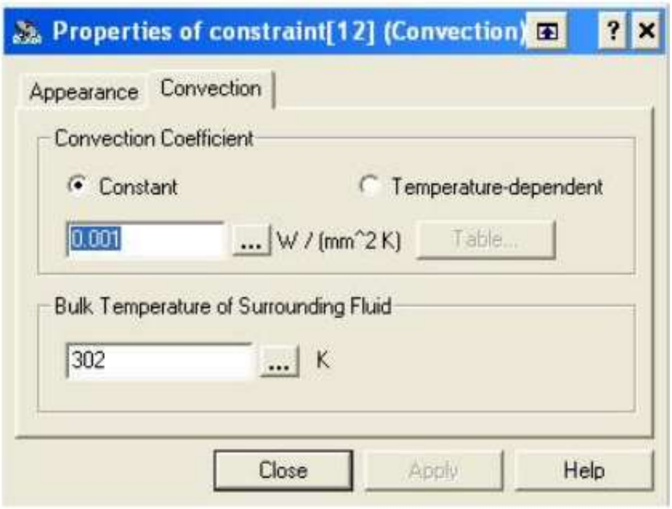


Figure 5. Convection dialog box at room temperature 29°C / 302 K

3.2.1 Temperature Analysis

3.2.1.1 On AMD . Parallel Fin Units

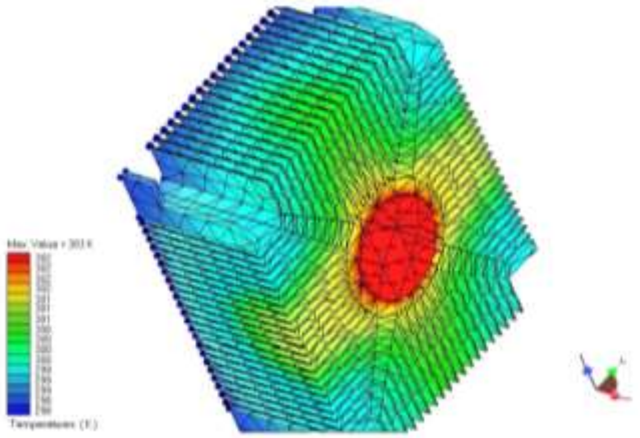


Figure 6. Temperature distribution for AMD . parallel fin units

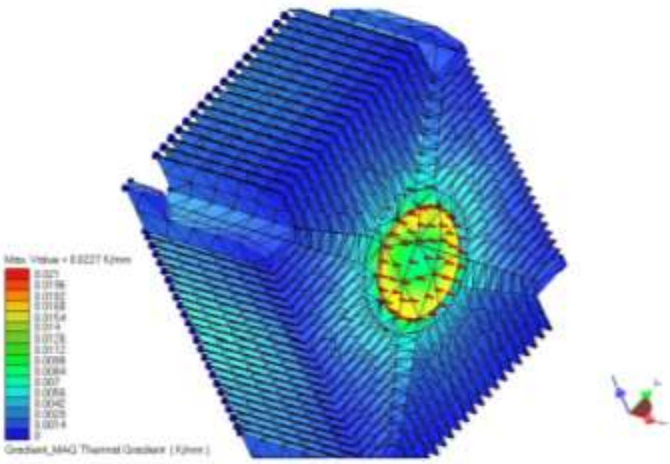


Figure 7. Thermal gradient for AMD parallel fin units

Table 3. Result of Temperature distribution for AMD . parallel fin unit

Name	Number of Nodes	Number of Elements
body[2]	41594	21476
	Minimum	Maximum
	Value	Value
Temperature (K)	302	303
Boundary Condition Reaction (W)	-0.744	5.9
Boundary Free Convection (W)	-1.12	-0.000233
Boundary Total Flow (W)	-1.12	-0.000233
Thermal Gradient (K/mm)	5.48e-6	0.00467
Thermal Flux (W/mm^2)	1.04e-6	0.000888

3.2.1.2 On Parallel Fin Unit

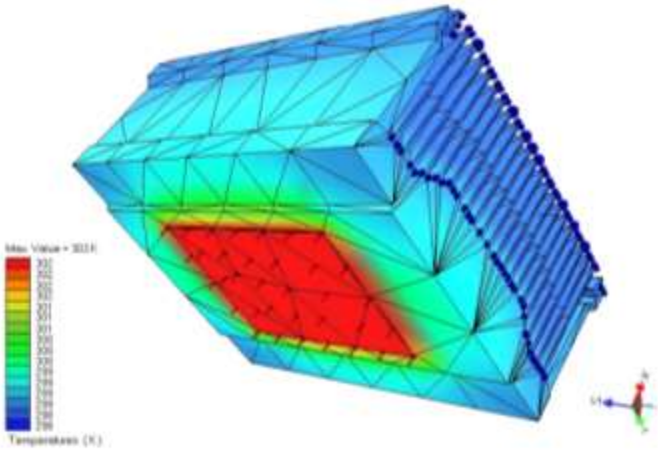


Figure 8. Temperature Distribution For Parallel Fin Unit

Table 4. Result of Temperature distribution for parallel fin unit

FEA Results for 'body[1]'		
	Minimum Value	Maximum Value
Temperature (K)	302	303
Boundary Condition Reaction (W)	-3.25	37.6
Boundary Free Convection (W)	-6.26	0.462
Boundary Total Flow (W)	-6.26	0.462
Thermal Gradient (K/m)	0.00087	7.93
Thermal Flux (W/m^2)	0.165	1.51e+3

3.2.1.3 On Circular Fin Unit

Table 5. Results Of Temperature Distribution For Circular Fin Units

FEA Summary		
Name	Number of Nodes	Number of Elements
sirkular	58062	29484
FEA Results for 'sirkular'		
	Minimum Value	Maximum Value
Temperature (K)	303	310
Boundary Condition Reaction (W)	-1.36	0.109
Boundary Free Convection (W)	-0.158	-2.2e-5
Boundary Total Flow (W)	-0.158	-2.2e-5
Thermal Gradient (K/mm)	0.000281	1.3
Thermal Flux (W/mm^2)	5.34e-5	0.246
Applied Heat (W)	-0.0604	0.0654

3.2.2 Analysis On Copper-Annealed With Fan Turns 2812 Rpm

3.2.2.1 On AMD paralel parallel fin units

Table 6. Result of Temperature distribution for AMD . parallel fin unit

FEA Summary		
Name	**Number of Nodes**	**Number of Elements**
body[2]	41594	21476
FEA Results for 'body[2]'		
	Minimum Value	**Maximum Value**
Temperature (K)	302	303
Boundary Condition Reaction (W)	-1.37	10.9
Boundary Free Convection (W)	-1.83	-0.000484
Boundary Total Flow (W)	-1.83	-0.000484
Thermal Gradient (K/mm)	4.98e-6	0.00417
Thermal Flux (W/mm^2)	1.96e-6	0.00164

3.2.2.2 On Circular Fin Unit

Table 7. Result of Temperature distribution for circular fin unit

FEA Summary		
Name	**Number of Nodes**	**Number of Elements**
sirkular	58062	29484
	Minimum Value	**Maximum Value**
Temperature (K)	303	307
Boundary Condition Reaction (W)	-1.5	0.121
Boundary Free Convection (W)	-0.099	-1.36e-5
Boundary Total Flow (W)	-0.099	-1.36e-5
Thermal Gradient (K/mm)	0.000285	0.693
Thermal Flux (W/mm^2)	0.000112	0.273
Applied Heat (W)	-0.0604	0.0654

3.3 Discussion

From the analysis results obtained in section 4.2. The comparison between the three forms of the fin unit and each material is presented in the following Figure and Histogram: In the simulation results, the temperature difference that occurs in the fin unit is displayed with color gradations. Each color shows the temperature distribution. So that it is clear that the parts of the heat distribution are better. The colors shown are shown in Figure 4.16

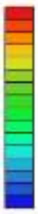


Figure 9. Heat Distribution Color

The red color indicates the maximum heat that occurs in the fin unit. While the blue color is the lowest heat distribution experienced by the fins. From Figure 4.17 it can be seen that sections 1 and 2 are the fins on the fin unit. While section 3 is the heat source of the fin unit. In section 1 the heat distribution that occurs is lower than in section 2. This is because the distance of section 1 is further from the heat source, and the distance between the fins is larger. From Figure 4.18 it can be seen that sections 1 and 3 are the fins on the fin unit. While part 2 is the heat source of the fin unit. In section 1 the heat distribution that occurs is lower than in section 3. This is because the distance of section 1 is further from the heat source. From Figure 4. 19 it can be seen that the temperature distribution that occurs in each fin is evenly distributed. This is because the distance and thickness of each fin is the same.

From the temperature comparison histogram in Figure 4.20, the highest maximum temperature is found in the circular fin unit with aluminum material at 310 K and the circular fin unit with copper material at 307 K. Meanwhile, in the other (parallel) fin unit with the two materials, they are the same, namely of 303 K. The minimum temperature that occurs in the AMD and parallel fin units with aluminum and parallel and AMD fin units with copper is the same, namely 302 K. While in the circular fin unit the minimum temperature that occurs is 303 K with aluminum and copper. aluminum and copper. The comparison according to the temperature increase/thermal gradient is shown in Figures 4.21 and 4.22 as follows:

From Figure 4.21 the minimum thermal gradient that occurs in the circular fin unit with the largest copper material is 0.000285 K/mm. While the lowest is the parallel fin unit with copper material of 0.000000507 K/mm.

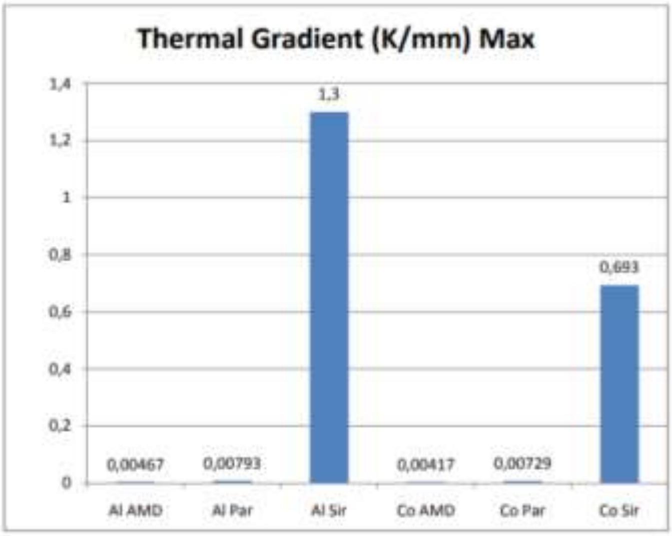


Figure 10. Thermal Gradient Max For Each Fin Unit

From Figure 4.22 the maximum thermal gradient that occurs in the circular fin unit with the largest aluminum material is 1.3 K/mm. While the lowest is the AMD parallel fin unit with copper material of 0.00417 K/mm. From the three histogram images above, it can be concluded that the circular fin type with 2024-T3 aluminum material has a better ability to conduct heat than other types of fins and materials. And the AMD parallel fin type with Copper Annealed material is not good at conducting heat.

4. CONCLUSION

From the operation of the simulation program Visual Nastran 2004 that has been made, several conclusions can be drawn, namely: (1) Study of the performance of the fin unit in dissipating the heat of the processor on a personal computer (PC) operating in the temperature range of 298 – 303 K. The type of fin used for research these are: (a) AMD parallel fins. (b) Parallel fins. (c) Circular fin. In this study, the materials studied for all types of fins are: (a) Aluminum 2024-T3 (b) Copper-Annealed., (2) Good heat distribution is delivered by circular fins with Aluminum 2024-T3 material of 1.3 K/ mm. Meanwhile, with Copper-Annealed material, the heat delivered is 0.693 K/mm., (3) Comparison of fin material based on heat distribution value: The use of Aluminum 2024-T3 material has a higher thermal gradient, which is equal to 1. 3 K/mm, compared to Copper-Annealed of 0.693 K/mm for the circular fin type. Thus Aluminum 2024-T3 is superior in conducting heat than Copper-Annealed in personal computer operations34., (4) The type of fin that best conducts heat is the circular fin unit. Because the thermal gradient is greater than the other types of fins.

Suggestions in this study are: (1) It is hoped that further simulations can be carried out using more supportive software such as ANSYS, Patran for heat transfer simulation and better software mastery. (2) It is hoped that this investigation will become a reference for investigations regarding heat transfer using the finite element method.

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