# Comparative Study Between Nanofluid and Distilled Water as Coolants in Central Processing Unit (CPU) of Computers

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***Abstract*: The growth of supercomputers is on the rise to meet the challenges of the digital world of technology. Computers are being used to solve long manual processes into quicker processes in a period effectively and efficiently. Due to the multiple work processes of computers, the central processing unit (CPU) is being overworked causing its temperature to increase rapidly. The fan goes overdrive to stabilize the set temperature of the CPU. Different research is being explored to develop new methods for cooling a computer CPU. This paper uses a comparative study, comparing the heat transfer performance of aluminum oxide nanofluids against the water alone. It was found that the heat transfer coefficient of the aluminum oxide increases from 79972.43 to 88782.86 W/m2 - K as the weight ratio decreases from 1:1/10 to 1:1/50. The results were evaluated and found that aluminum oxide nanofluid manifests greater performance than distilled water in terms of absorbing heat from the central processing unit.**

***Keywords*: central processing unit, convective heat transfer, heat transfer coefficient, nanofluid.**

## 1. Introduction

The rising thermal needs of modern central processing units (CPUs) have demanded improved cooling methods to prevent overheating and assure peak performance. Nanofluids, which are designed suspensions of nanoparticles in base fluids such as water, have emerged as a transformative alternative to traditional coolants due to their superior thermal qualities [1]. Nanofluids with titanium dioxide ($TiO_2$), alumina ($Al_2O_3$), carbon nanotubes (CNTs), and other nanoparticles improve heat transfer rates compared to pure water or standard coolants, according to experiments. $TiO_2$/water nanofluids at 0.05% volume concentration lowered CPU temperatures by up to 6.89% during high-load circumstances, exceeding traditional systems [1]. Similarly, CNT-based nanofluids reduced processor temperatures by 22%, demonstrating their potential as next-generation thermal management solutions [2].

Practical uses for using nanoparticles as coolants in electronics have been observed in several fields, especially in high-power electronic systems where effective thermal control is essential.

Liquid cooling systems use nanofluids, which are suspensions of nanoparticles in a base fluid, to improve heat transfer. For example, it has been tested that nanofluids such as $Al2O_3$ water mixes can increase cooling efficiency in data centers by boosting the heat transfer coefficient and thermal conductivity [3]. The integration of nanofluids into vapor chambers and heat pipes is also being done to improve thermal performance while lowering system size and noise. These developments make it possible to create cooling systems that are more compact, lightweight, and effective all of which are critical for preserving the dependability and functionality of contemporary electronics [4]. As investigations continue, the potential of novel materials such as carbon nanotubes and graphene in thermal management applications is being investigated.

The use of nanofluids tackles fundamental issues in electronic cooling, such as spatial restrictions and increasing power densities. Their increased thermal conductivity, caused by nanoparticle-fluid interactions and micro convection phenomena, allows for more efficient heat dissipation, which directly improves CPU dependability and durability [5]. This correlates to decreased energy usage and operational costs for data centers and high-performance computing, as cooling systems run more efficiently on smaller sizes. Nanofluids' tunable features enable optimization for specific applications. For instance, $SiO_2$/water nanofluids have high surface-to-volume ratios, resulting in superior heat transfer coefficients.

To achieve scale implementation, more studies are necessary to address issues including nanoparticle sedimentation and long-term stability. Despite of these challenges, the use of nanofluids is a significant development in thermal engineering that provides a viable approach to satisfy the cooling requirements of ever-more-powerful computer technology. This has led of coming up with the study with the aim of experimentally and numerically investigate the heat transfer performances of aluminum oxide nanofluid compared to that of distilled water in central processing units of computers.

## 2. Materials and Methodology

### *A. Preparation of the Nanofluid*

The type of nanofluid as a coolant for the central processing unit (CPU) that was utilized in this study is aluminum oxide.

Table 1
Variation and proportion of distilled water and aluminum oxide

| Weight of distilled water (grams) | Mass of aluminum oxide nanofluids (grams) | Total mass (grams) | Weight ratio |
|---|---|---|---|
| 280 | 28 | 308.00 | 1:1/10 |
| 280 | 14 | 294.00 | 1:1/20 |
| 280 | 9.33 | 289.33 | 1:1/30 |
| 280 | 7 | 287.00 | 1:1/40 |
| 280 | 5.6 | 285.60 | 1:1/50 |

The weight of the nanofluids was taken by 1 part of distilled water which is fixed at 280 grams of aluminum oxide nanoparticles, with distilled water maintained at 20 °C so that one gram of distilled water is equal to 1 ml of distilled water. To prevent sedimentation of the nanoparticle, an agitator is utilized to mix thoroughly as shown in the experimental set-up in Fig. 1. To test the heat transfer effect on the central processing unit (CPU), weight ratios of aluminum oxide nanoparticles are varied as 1:1/10, 1:1/20, 1:1/30, 1:1/40 and 1:1/50 as shown in Table 1.

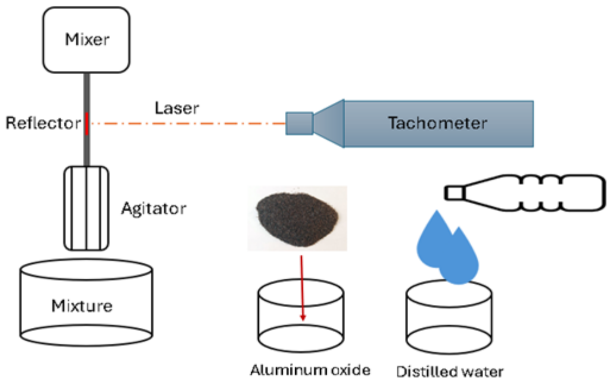

Fig. 1. Preparation set-up of aluminum oxide nanoparticles

### *B. Convection Test of Distilled Water*

Table 2
Measured specific heat of aluminum oxide nanofluid

| Weight ratio | Mass (grams) | Time (sec) | Change in temperature (℃) | Heat supplied (W) | Specific heat (J/kg-K) |
|---|---|---|---|---|---|
| 1:1/10 | 0.3080 | 272 | 80 | 220.67 | 2435.93 |
| 1:1/20 | 0.2940 | 271 | 80 | 220.67 | 2542.54 |
| 1:1/30 | 0.2893 | 283 | 80 | 220.67 | 2697.95 |
| 1:1/40 | 0.2870 | 290 | 80 | 220.67 | 2787.16 |
| 1:1/50 | 0.2856 | 309 | 80 | 220.67 | 2984.33 |

To do the convection test of distilled water, first, mount the CPU water block, which usually installs the mounting to the radiator as shown in Fig. 2. The radiator can be installed over any fan grate that's large enough, and the simplest radiators are designed with screw holes that have the same dimensions as standard case fans. Once the radiator is in place cut the tubing from the CPU to the right length and connect it to the radiator, making sure not to kink in the process.

Fill with the base fluid. Add the pump, where most pumps are small and can be attached almost anywhere in your case, using screws or Velcro tape. After the cooling system is installed, turn the computer on. Ensure the computer is running at the maximum load, you can check the load using an open hardware monitor. After the computer is running at full load. You can now check the core's temperature using an open hardware monitor. Take and record the temperature.

### *C. Convection Heat Transfer Test of Nanofluid*

To do the convection test of the nanofluid, drain the distilled water from the radiator and fill it up with the aluminum oxide nanofluid. Let the computer on, make sure the computer is running at maximum load, and check the loading using an open hardware monitor. Take the temperature of the core where the cooling fluid is aluminum oxide nanofluid. Record the necessary data then compare if the aluminum nanofluid are more suitable cooling fluid than the distilled water.

## 3. Results and Discussion

### *A. Specific Heat of Aluminum Oxide Nanofluid at Different Weight Ratios*

The specific heat capacity of a substance is defined as the amount of heat required to raise one unit temperature of a mass unit. Heat capacity is a crucial quantity for predicting heat transfer capacity, hence its determination is critical [6]. Specific heat capacity in nanofluid applications can vary depending on the particle used and the type of base fluid [7].

The specific heat of the said nanofluid was filled in the electric heater. The experiment was performed three times as the experimental value to measure the heat supplied by the electric heater which was used to calculate the specific heat of the liquid inside the heater. The specific heat was calculated by equating it with the heat supplied by the heater divided by the mass flow and the temperature change and the results are shown in Table 2. From Fig. 3, the trend in the graph shows an increased specific heat as the weight ratio reduces.

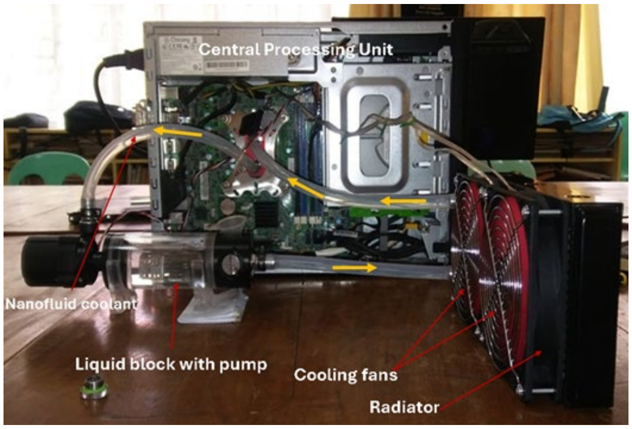

Fig. 2. Cooling system set-up in the central processing unit (CPU)

This implies that at low weight ratios (<1%), the base fluid constitutes most of the nanofluid. For example, in water-based systems, the high specific heat of water dominates, resulting in values closer to pure water as nanoparticle loading decreases. Moreover, as the nanoparticle concentration increases, the higher-specific-heat base fluid displaces the nanofluid's overall capacity to store thermal energy.

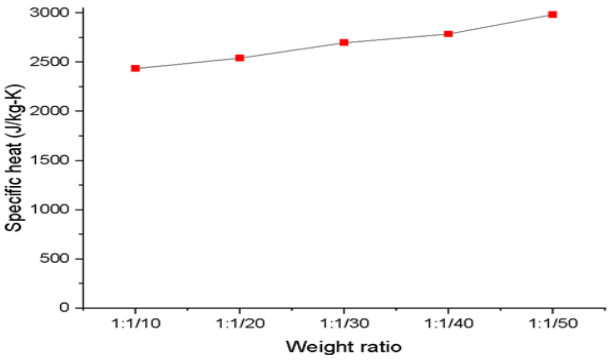

Fig. 3. Graph on the specific heat of aluminum oxide at different weight ratios

### *B. Comparison on the Heat Absorbed Between Aluminum Oxide Nanofluid and Distilled Water at Different Weight Ratios*

Aluminum oxide ($Al_2O_3$) nanoparticles scattered in coolant exhibit higher heat absorption which can be seen in Table 3 compared to purified water in CPU cooling systems due to improved thermal conductivity. $Al_2O_3$ nanofluids facilitate heat transfer by increasing surface area and disturbing boundary layers. Studies suggest that a 0.5% concentration reduces CPU temperatures more effectively than distilled water [8]. Although distilled water has good thermal characteristics (specific heat capacity of 4187 J/kg-K) as shown in Table 4, it lacks nanoparticle improvements and can become conductive over time due to trace ion dissolution from system components. Moreover, as the weight ratio decreases aluminum oxide nanofluid increases up to 1/160 then decreases when the weight ratio decreases. The heat rejected by the central processing unit is equal to the heat absorbed by the nanofluids and the distilled water. The heat rejected by the CPU is assumed to be adiabatic so equal to the heat convection.

The consistency in heat absorption by distilled water as shown in Fig. 4 can be attributed to several factors such as stable thermal properties wherein distilled water maintains a constant specific heat capacity and thermal conductivity, guaranteeing dependable heat transmission under typical operational settings. Second, there is efficient heat dissipation of the distilled water as coolant returns to the CPU at a constant temperature thanks to the radiator and fan arrangement, which guarantees effective heat dissipation.

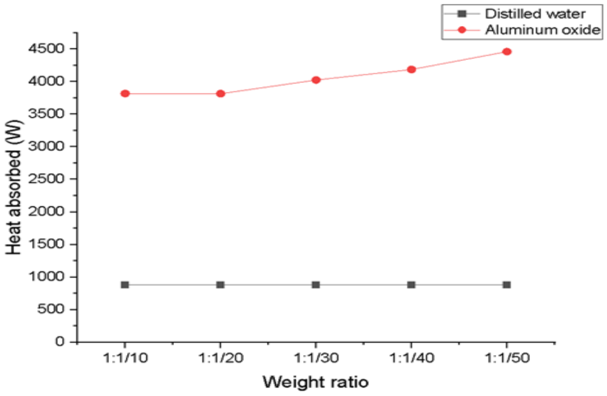

Fig. 4. Comparison graphs on heat absorbed between distilled water and aluminum oxide

Table 3
Measured heat absorbed by aluminum oxide nanofluid

| Weight ratio | Mass (kg) | Change in temperature (℃) | Specific heat (J/kg-K) | Heat absorbed (W) |
|---|---|---|---|---|
| 1:1/10 | 0.3080 | 19.1 | 2435.93 | 3818.68 |
| 1:1/20 | 0.2940 | 19.6 | 2542.54 | 3815.36 |
| 1:1/30 | 0.2893 | 19.8 | 2697.95 | 4024.97 |
| 1:1/40 | 0.2870 | 20.1 | 2787.16 | 4187.02 |
| 1:1/50 | 0.2856 | 20.1 | 2984.33 | 4461.34 |

Table 4
Measured heat absorbed by distilled water

| Weight ratio | Mass flow rate of mixture (kg) | Change in temperature (℃) | Specific heat (J/kg-K) | Heat absorbed (W) |
|---|---|---|---|---|
| 1:1/10 | 0.072916 | 9.6 | 4187 | 879.26 |
| 1:1/20 | 0.072916 | 9.6 | 4187 | 879.26 |
| 1:1/30 | 0.072916 | 9.6 | 4187 | 879.26 |
| 1:1/40 | 0.072916 | 9.6 | 4187 | 879.26 |
| 1:1/50 | 0.072916 | 9.6 | 4187 | 879.26 |

### *C. Comparison of the Convective Heat Transfer Between Aluminum Oxide Nanofluid and Distilled Water at Different Weight Ratios*

There are multiple reasons for the rising trend in aluminum oxide ($Al2O_3$) nanofluids' convective heat transfer coefficient as coolants as shown in Table 5. One major factor is enhanced thermal conductivity, which is made possible by the addition of $Al2O_3$ nanoparticles, which raises the fluid's overall thermal conductivity and facilitates more effective heat transmission [9]. Additionally, by enhancing the fluid's mixing and turbulence, microconvection currents produced by the Brownian motion of nanoparticles improve convective heat transmission [10]. When Al2O3 nanofluids are used instead of base fluids like water, the Nusselt number, a gauge of convective heat transfer efficiency, also rises, suggesting better heat transfer performance [11].

On the other hand, because of its stable thermal characteristics and the absence of nanoparticle-induced factors that change fluid dynamics, the convective heat transfer coefficient in distilled water remains generally constant under certain operating circumstances as shown both in Table 6 and Fig. 5. Distilled water has fewer factors influencing heat transfer than nanofluids because it does not contain nanoparticles that improve thermal conductivity through microconvection or Brownian motion [12].

## 4. Conclusion

In summary, the comparison of distilled water and aluminum oxide ($Al2O_3$) nanofluids as coolants in central processing units (CPUs) identifies clear benefits and drawbacks for each alternative. Compared to distilled water, aluminum oxide nanofluids have higher convective heat transfer coefficients and thermal conductivity, which makes them more effective at dissipating heat from CPUs. This is especially helpful in high-performance computer applications where better cooling capabilities are needed due to greater heat loads. Increased viscosity and possible sedimentation problems are two complications that can arise from using nanofluids, which may call for extra system design considerations. Although distilled water may not have the same level of thermal conductivity as nanofluids, it is still a viable option for many users since it can be made more effective with chemicals that stop corrosion and biological development. The decision between $Al2O_3$ nanofluids and distilled water ultimately comes down to the particular needs of the cooling system, such as the necessity for good thermal performance in comparison to ease of use and affordability.

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