



Temperature Control Cooling System of a CPU

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Introduction

- Excessive heat can degrade **CPU performance** and lifespan, leading to system instability and potential hardware failures.
- Over the years, various **cooling methods** have been employed to dissipate heat from CPUs, ranging from simple heat sinks with air cooling to more sophisticated liquid cooling systems.
- In this study, we focus our attention on finding a new CPU cooler design that provides a more efficient **heat performance** at a **low-noise** level under the confined space constraints of a desktop computer chassis.

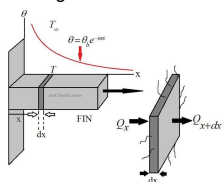
Existing CPU Coolers

- **Air Cooling** - It involves the use of heat sinks, which are metal structures with fins that dissipate heat away from the CPU.
- **Liquid Cooling** - Liquid cooling systems use a closed-loop of coolant to transfer heat away from the CPU.
- **Phase Change** - Phase-change cooling systems use refrigeration techniques to cool.



Principles of Heat Transfer

- **Conduction and Convection** - Heat from the CPU or other heat source is conducted through the base of the fins.



$$\frac{dQ}{dx} = hP(T - T_{\infty})$$

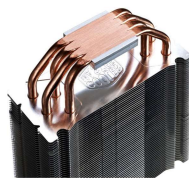
$$-\frac{d}{dx} \left(-KA \frac{dT}{dx} \right) = hP(T - T_{\infty})$$

$$\frac{d^2 T}{dx^2} = \frac{hP}{KA} (T - T_{\infty})$$

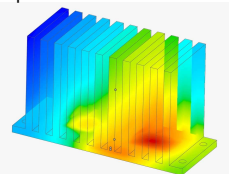
$$\text{Let } T - T_{\infty} = \theta$$

$$\frac{d^2 \theta}{dx^2} = \frac{hP}{KA} \theta$$

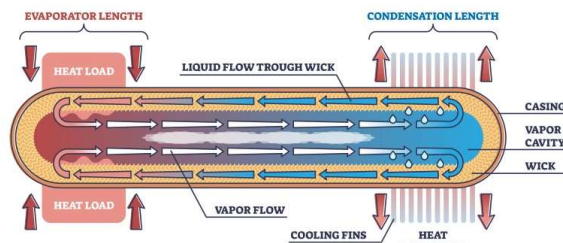
Why use heat pipes for CPU cooling?



- **Enhanced Heat Transfer**: Heat pipes are extremely efficient at transferring heat due to their use of phase change of the working fluid inside them.
- **Reduced Noise**: Systems utilizing heat pipes can often achieve effective cooling with less dependence on fans
- **Effective Heat Distribution** - Heat pipes can quickly transport heat from the heat source (CPU) to the heat sink where it can be dissipated over a larger area.
- **Maintenance** - Heat pipes have no moving parts, making them highly reliable and low maintenance compared to mechanical cooling components.



HEAT PIPE

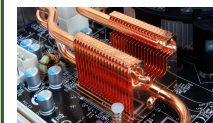


Thermal Resistance

- The thermal performance of a CPU describes its efficiency in managing heat generated during operation.
 - Typically, the total thermal resistance (R_t) is used to evaluate the thermal performance of CPU coolers.
- $$R_t = \frac{T_j - T_a}{Q}$$
- $$R_t = R_c + R_b + R_{hp} + R_{fa}$$
- These resistances can be used to assess the performance of each component and improve the overall efficiency of the heat transfer process.

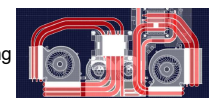
Applications

- **Data Centers**: Liquid cooling solutions are increasingly adopted in **data centers** to manage the heat generated by high-density server racks, improving energy efficiency and reducing operating costs.
- **Gaming PCs**: Enthusiasts and gamers utilize liquid cooling to overclock processors and graphics cards
- **High-Performance Computing (HPC)**: Liquid cooling is vital for HPC systems, enabling reliable cooling of processors, GPUs, and memory modules to sustain peak performance during intensive computational tasks.
- **Industrial Machinery**: Liquid cooling plays crucial role in industrial applications, such as CNC machines



Conclusion

- The new design achieves a total thermal resistance lower than commercially available coolers because since Q is const, the temperature difference reduces.
- **Reduced noise level** - The new design operates at a noise level which is quieter than most conventional coolers.
- The new design achieves its performance without requiring additional heat pipes, keeping the cost and size comparable to existing coolers.
- **Reduced power consumption** - The lower fan speed required by the new design reduces computer power consumption.



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References

1. Thermal management system of CPU cooling with a novel short heat pipe cooling system
2. <https://www.msi.com/Landing/Cooling-solution-matters/nb>
3. <https://courses.ansys.com/index.php/courses/thermal-management-of-cpus/lessons/heat-management-of-cpus-using-ansys-discovery-heat-sink-lesson-2/>
4. On the thermal cooling of central processing unit of the PCs with vapor chamber
5. https://www.global.dnp.biz/column/detail/10162360_4117.html