CHAPTER 6

ELECTRONIC LIQUID COOLING SYSTEMS

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1. INTRODUCTION

The development of technology and the corresponding increase in energy demand require more efficient use of energy day by day. Researchers are making significant efforts on the management of traditional and renewable energy sources. They focused on making energy producing and consuming systems more efficient, especially on providing the best thermal energy management. The development of smaller and more efficient systems is one of these innovative areas. To ensure the energy management of these small and efficient systems, an important cooling need has emerged, especially for electronic devices [1].

The cooling need in electronic devices is provided by various methods. Especially in the last 30 years, many technological developments in this field have taken place rapidly. Smartphone, computer, etc. Compact designs of devices such as smart phones, computers, etc. require the use of higher efficiency systems in a smaller space. This leads to higher efficiency from smaller components, and therefore to an increase in the cooling requirement per area. In this respect, cooling of electronic systems (providing thermal energy management in this way) has become an important research topic [3].

Different systems have been developed for the cooling of electronic systems. In devices with high mobility, systems with thermosiphon effects such as heat pipes and fan-assisted air-cooled systems are used. In systems where higher performance is required, higher-capacity air cooling and liquid cooling methods are used. In different situations, thermoelectric cooling can also be used with and independently of these systems. In this respect, electronic cooling systems can

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REFERENCES

1. Arshad, M. U., Ghani, M. U., Ullah, A., Güngör, A., & Zaman, M. (2019). Thermodynamic analysis and optimization of double effect absorption refrigeration system using genetic algorithm. *Energy Conversion and Management*, *192*, 292-307.
2. Gungor, A., Akyüz, A. Ö., & Tuncer, A. D., (2020). *Scientific Studies on The Edge of Global Warming: Carbon Footprint Sustainable Environment And Future.* Ankara: Nobel Yayınevi.
3. Adham, A. M., Mohd-Ghazali, N., & Ahmad, R. (2013). Thermal and hydrodynamic analysis of microchannel heat sinks: A review. *Renewable and Sustainable Energy Reviews*, *21*, 614-622.
4. Shabany, Y. (2009). *Heat transfer: thermal management of electronics*. CRC press.
5. Zhang, Y. P., Yu, X. L., Feng, Q. K., & Zhang, R. T. (2009). Thermal performance study of integrated cold plate with power module. *Applied Thermal Engineering*, *29*(17-18), 3568-3573.
6. Huo, Y., Rao, Z., Liu, X., & Zhao, J. (2015). Investigation of power battery thermal management by using mini-channel cold plate. *Energy Conversion and Management*, *89*, 387-395.
7. Cova, P., Santoro, D., Spaggiari, D., Portesine, F., Vaccaro, F., & Delmonte, N. (2020). CFD modeling of additive manufacturing liquid cold plates for more reliable power press-pack assemblies. *Microelectronics Reliability*, *114*, 113734.
8. Kandlikar, S. G., & Hayner, C. N. (2009). Liquid cooled cold plates for industrial high-power electronic devices—thermal design and manufacturing considerations. *Heat transfer engineering*, *30*(12), 918-930.
9. Ramesh, K. N., Sharma, T. K., & Rao, G. (2021). Latest advancements in heat transfer enhancement in the micro-channel heat sinks: a review. *Archives of Computational Methods in Engineering*, *28*(4), 3135-3165.
10. Kandlikar, S. G., & Grande, W. J. (2003). Evolution of microchannel flow passages thermohydraulic performance and fabrication technology. *Heat transfer engineering*, *24*(1), 3-17.
11. Mehendale, S. S., Jacobi, A. M., & Shah, R. K. (2000). Fluid flow and heat transfer at micro-and meso-scales with application to heat exchanger design.
12. Wang, H. L., Wu, H. C., Wang, S. K., Hung, T. C., & Yang, R. J. (2013). A study of mini-channel thermal module design for achieving high stability and high capability in electronic cooling. *Applied thermal engineering*, *51*(1-2), 1144-1153.
13. Alihosseini, Y., Targhi, M. Z., Heyhat, M. M., & Ghorbani, N. (2020). Effect of a micro heat sink geometric design on thermo-hydraulic performance: A review. *Applied Thermal Engineering*, *170*, 114974.
14. Lin, L., Zhao, J., Lu, G., Wang, X. D., & Yan, W. M. (2017). Heat transfer enhancement in microchannel heat sink by wavy channel with changing wavelength/amplitude. *International Journal of Thermal Sciences*, *118*, 423-434.
15. Nilpueng, K., Mesgarpour, M., Asirvatham, L. G., Dalkılıç, A. S., Ahn, H. S., Mahian, O., & Wongwises, S. (2021). Effect of pin fin configuration on thermal performance of plate pin fin heat sinks. *Case Studies in Thermal Engineering*, *27*, 101269.
16. Radmard, V., Hadad, Y., Rangarajan, S., Hoang, C. H., Fallahtafti, N., Arvin, C. L., ... & Sammakia, B. G. (2021). Multi-objective optimization of a chip-attached micro pin fin liquid cooling system. *Applied Thermal Engineering*, *195*, 117187.
17. Radmard, V., Hadad, Y., Rangarajan, S., Hoang, C. H., Fallahtafti, N., Arvin, C. L., ... & Sammakia, B. G. (2021). Multi-objective optimization of a chip-attached micro pin fin liquid cooling system. *Applied Thermal Engineering*, *195*, 117187.
18. Chen, C., Yang, S., & Pan, M. (2021). Microchannel structure optimization and experimental verification of a plate heat exchanger. *International Journal of Heat and Mass Transfer*, *175*, 121385.
19. Tan, H., Wu, L., Wang, M., Yang, Z., & Du, P. (2019). Heat transfer improvement in microchannel heat sink by topology design and optimization for high heat flux chip cooling. *International Journal of Heat and Mass Transfer*, *129*, 681-689.

20. Colangelo, G., Favale, E., Milanese, M., De Risi, A., & Laforgia, D. (2017). Cooling of electronic devices: Nanofluids contribution. *Applied Thermal Engineering*, *127*, 421-435.
21. Saidina, D. S., Abdullah, M. Z., & Hussin, M. (2020). Metal oxide nanofluids in electronic cooling: a review. *Journal of Materials Science: Materials in Electronics*, *31*(6), 4381-4398.
22. Japar, W. M. A. A., Sidik, N. A. C., Aid, S. R., Asako, Y., & Ken, T. L. (2018). A comprehensive review on numerical and experimental study of nanofluid performance in microchannel heatsink (MCHS). *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*, *45*(1), 165-176.
23. Aglawe, K. R., Yadav, R. K., & Thool, S. B. (2021). Preparation, applications and challenges of nanofluids in electronic cooling: A systematic review. *Materials Today: Proceedings*, *43*, 366-372.