Heat transfer intensification in two-phase flow by tailoring the working medium distribution

Every electronic device must be operated below a specified temperature level to warrant its reliability and long-term service life. The upper-temperature level that these devices can survive depends on the types of electronic components used in them. Broadly recommended upper limits of temperatures based on their application are as follows:

- commercial applications - up to 70°C,
- industrial applications - up to 85°C,
- military applications - up to 125°C.

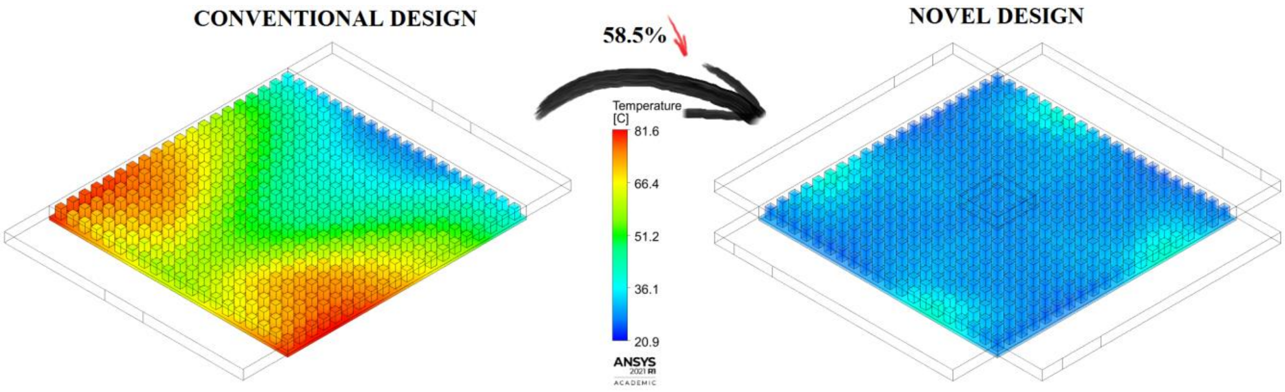
In 1971, Intel introduced the world's first microprocessor, Intel 4004. It had merely 2 300 transistors with a clock frequency of 750 kHz. Intense rivalry among the major players in the business has kept the fastest microprocessor development race still alive. Unveiled on 16th October 2023, the 14th generation Intel microprocessor i9-14900K claims to be the world's fastest desktop processor with 24 cores, 32 threads, and 6 GHz frequency. Its peak power load of 253 W is limited to not exceed a maximum junction temperature (the highest semiconductor's operating temperature). The efficient and fast heat removal from the microprocessor surface is one of the barriers to their development.

The fluid distribution seems crucial in heat sink operation, especially in electronics cooling applications. The uneven velocity profile over the surface causes a non-uniform temperature field, deterioration of heat transfer, and hotspots appearance. While the electronics operation is limited by a junction temperature, after exceeding it even in a single point, thermal throttling (connected with a performance reduction) is applied in the electronic device to prevent permanent damage. Thus, the uniform temperature over the heat sink's surface is of great importance for the high performance of electronics. Increasing the temperature uniformity while reducing the maximum temperature gives a possibility to increase the microprocessor power until the junction temperature is reached.

The research questions arise:

- How to remove heat from the electronics' surface and keep a uniform temperature?
- How do the multiple inlet designs affect the electronics' temperature and hence their performance?
- Is it possible to increase the heat removed from the surface by making a temperature more uniform and simultaneously reduce the surface's maximum temperature which will allow to increase the electronics performance?

Thus, the project aims to improve the fluid distribution over the micro pin fin heat sink's (MPFHS) surface in the cooling of electronics by incorporating novel MPFHS designs and reducing the temperature of electronics. The preliminary results showed that about 58.5% of temperature reduction can be achieved by introducing multiple inlets with cyclone generation instincts compared to the conventional design. This reduction means, that the performance of electronic equipment can be improved without the danger of thermal throttling or electronics damage.



The project research is based on the experimental evaluation of various MPFHS designs and various working mediums to find the best solution for electronics' cooling. The parameters like temperature, pressure, and velocity for various operating conditions of electronic systems will be experimentally measured and then quantitative parameters, which describe the system, will be calculated to compare and define the optimal design.