

Modern electronic devices, energy systems, and space technologies require increasingly efficient cooling solutions that are also compact and lightweight. In response to these demands, scientists around the world are investigating so-called *minichannels* - microscopic channels with diameters of less than 2-3 mm, through which coolant flows to remove excess heat.

The goal of this project is to investigate how a fluid, heated along the flow direction from the channel wall, behaves inside two types of such channels: annular (formed between two coaxial tubes) and rectangular (e.g. machined into a metal plate). Although this geometric difference may seem minor, it has a major impact on cooling efficiency, flow stability, and the onset of boiling - a phenomenon that can both enhance heat transfer and disrupt system operation.

The research team will design a state-of-the-art experimental platform capable of precisely measuring temperature, pressure, and fluid flow, as well as recording high-speed video of the boiling process. A variety of fluids will be tested - from distilled water to modern refrigerants - along with surfaces of varying wettability: hydrophilic (fluid-attracting) and hydrophobic (fluid-repelling).

The most innovative aspect of the project is the application of artificial intelligence (AI) to develop equations that describe heat transfer and boiling processes. Rather than manually fitting mathematical models, AI algorithms will “learn” from experimental data how heat transfer efficiency depends on the type of fluid, the channel’s shape and dimensions, and surface treatment. These results will be made publicly available as open tools for engineers and researchers.

The project brings together expertise in fluid mechanics, thermal engineering, and modern computing methods. Its outcomes could be applied to the cooling of processors, electric vehicle systems, satellite equipment, and chemical microreactors. Ultimately, the project will enable the design of more efficient, safer, and more environmentally friendly heat exchange systems.