Abstrakt

In this doctoral dissertation, experimental studies were conducted on the heat exchange process using two heat exchangers: one with a heating plate containing two minichannels and another with a solar cell equipped with a group of minichannels. These studies were performed for three spatial orientations and nine settings of mass flow rates of working fluids. The heat transfer coefficients were derived based on tests with the heating plate featuring two minichannels (for five heat flux densities) and the solar cell with a group of minichannels (for six heat flux densities) in the region of single-phase convection and the initiation of subcooled boiling.

The research was preceded by an analysis of the current state of knowledge in the field of compact heat exchangers and hybrid PVT energy storage systems used for cooling solar cells. The achievements in this area to date were presented. The research procedure and measurement setups were detailed, including the module with two minichannels and the solar module with a group of minichannels.

A computational method (one-dimensional approach) was developed to determine local heat transfer coefficients at the interfaces: heating plate-fluid in the hot minichannel, fluid in the hot minichannel-middle plate, middle plate-cooling fluid, and cooling fluid-closing plate of the exchanger. To verify the heat transfer coefficient calculations from the 1D approach, they were compared with the results of the 2D computational method. The numerical calculation methodology in the Simcenter STAR-CCM+ program along with the CFD model for the two experimental modules was described to verify and check the heat transfer coefficient results with the developed 1D approach.

The characteristics of the individual elements of the photovoltaic system were presented, and the basic parameters describing the module's performance under load, thermal efficiency, and useful power of the PVT module were determined. The study results concerning local heat transfer coefficients were developed and compared with other computational methods (2D). Temperature fields were described using thermographic cameras and thermocouples for analysis. The impact of the compact heat exchanger's position during subcooled boiling for two parallel rectangular minichannels was analyzed. In the hot channel, the refrigerant FC-72 or HFE-649 was tested, and in the second cold minichannel, water was used. The influence of selected parameters and factors on the intensification of heat exchange during the working fluid flow in minichannels was analyzed.

The obtained results were compared using 1D and 2D computational approaches and numerical simulations in the Simcenter STAR-CCM+ program. The heat transfer coefficient results for the middle copper and silver plates were analyzed, with the Ag middle plate coefficient values being higher than those for the Cu plate. The further part of the study presents an analysis of the obtained results from 1D and 2D calculations and the known authors' criterion equations, where the most suitable results were selected. The maximum relative temperature differences determined from experimental measurements and numerical calculations in the Simcenter STAR-CCM+ program, as well as the relative differences between the heat transfer coefficients α_{23} obtained from the criterion equations mentioned for the heat exchanger with the heating plate, were presented. The last chapter of the dissertation describes the analysis of the temperature power coefficient for the *PVT* module and the use of a compact heat exchanger for cooling photovoltaic system components. Finally, measurement errors and the parameters of the experimental tests conducted were compiled.