

Summary

The present thesis describes thermal and flow phenomena occurring in smooth tubes connected by fins. The current state of art observation has been discussed. In the further part of the thesis was analyzed the calculation process, which was used to create a numerical algorithm in the MATLAB program. Experimental investigations related to the determination of temperature distribution in one-sidedly heated smooth tubes connected by fins were discussed.

Chapters 1 and 2 present the objectives of this thesis. It was planned to create a numerical model allowing to determine the temperature distribution and thermal stresses distribution in smooth waterwall tubes connected by fins, installed in a boiler operating at supercritical parameters. The thesis has been presented that the differentiation of the heat flux on the surface of waterwall tubes influences the increase of thermal stresses in the waterwall tubes and the fins that connect them. The thesis was verified by creating a numerical algorithm and comparing the results obtained from it with the results obtained from the CFD model and measurements carried out on a dedicated experimental stand.

Chapter 3 describes the current state of the art. The presented works have been divided into studies on the operating conditions of boilers and those describing the operating conditions of waterwall tubes. Among the works that discuss the heat transfer process in the evaporator tubes, there are works describing various models for determining the temperature distribution in a single tube.

Chapter 4 is devoted to the analysis of thermal-flow phenomena - the used mass, momentum and energy balance equations are presented. The equations allowing to determine the temperature distribution in the half of the cross-section of the waterwall tube connected to the fin were also presented. After modification, they were used to create a proprietary numerical algorithm. The equations allowing to determine the coefficient of linear friction losses, the Nusselt number and the heat transfer coefficient for smooth tubes are also discussed.

Chapter 5 describes the course of the heat exchange process in the connected waterwall tubes operating in the combustion chamber of the supercritical boiler. Technical conditions in supercritical boilers are discussed, taking into account the changes in the geometry of the evaporator tubes. The dependencies allowing to determine the temperature distribution at selected points of the entire cross-section of the waterwall tube connected to fins were determined, which can be used during the analysis carried out for several connected tubes.

Chapter 6 describes the numerical algorithm that allows to determine the temperature distribution in several waterwall tubes connected by fins. In the proposed numerical program, it is possible to assume even or uneven heating of the pitch of the waterwall tubes. In order to increase the accuracy of the simulation, the thermodynamic parameters

for each of the characteristic points of the system and for the medium flowing inside the waterwall tubes are determined at each time step. The obtained temperature and stress distributions were presented for a few selected cross-sections of a system consisting of three tubes, during even or uneven heating. The obtained temperature distributions were verified with the results obtained from the CFD model created in the ANSYS Fluent software.

Chapter 7 discusses the main assumptions and elements of the experimental stand allowing to determine the temperature distribution on the frontal surface of three vertically placed smooth tubes connected by fins. The parameters of the devices and measuring apparatus used were discussed, as well as the distribution of measuring points throughout the system.

Chapter 8 presents the effects of experimental verification. It compares the results obtained during the experimental tests carried out on the test stand and those determined from the proprietary numerical algorithm. The discussion of errors determined for the obtained temperature distributions allows to conclude that the proposed calculation algorithm ensures a satisfactory accuracy of calculations and the results obtained using it can be used, for example, to determine the stress distribution for the analyzed model.

Conducted simulations and experimental research allowed to achieve the set goal and confirm the thesis. The proposed numerical algorithm makes it possible to determine the temperature distribution in several connected waterwall tubes and fins connecting them for even and uneven heating of subsequent tube spacing divisions included in the analyzed model. The determined temperature distribution can be used to determine the thermal stress distribution for the cross-section of the analyzed system.