Application of infrared thermography for validation of numerical analyses results of a finned cross-flow heat exchanger with non uniform flow of the agents

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Extended abstract

The thermodynamic analysis of a ribbed cross-flow heat exchanger of the liquid-gas type is the subject of the research. The basic problem in computations of such a type of heat exchangers is to calculate the heat transfer coefficient from the ribbed surfaces to gas. The diversity of the local values of the heat transfer coefficient resulting from the unequal flow of the agents through the exchanger additionally complicates the analysis. During the research the form of the unequal distribution of the air flow rate at the inlet and outlet cross section of a typical automotive heat exchanger was experimentally determined.

The general aim of the work was determination of the influence of disturbances in velocity field of inlet air on the operation efficiency of heat exchanger under consideration. This problem is important in design technology of air coolers for car engines.

The simplified scheme of the laboratory experimental stand shown in two positions is presented in Fig. 1. The temperature and velocity of cooling air at selected nodes of measuring net were continuously measured during the experiments. These parameters were measured by means of thermo-anemometric sensor. The shifting of the sensor was controlled by a computer and the measuring results were recorded by computer as well. Additionally other parameters were measured as inlet and outlet water temperature, flow rate of water and total flow rate of air.

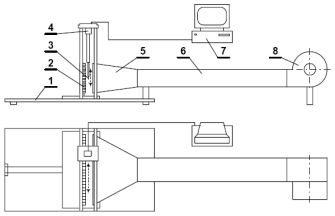

Fig. 1. *The diagram of the measuring station – air supply module - (1 - support plate, 2 - considered heat exchanger, 3 - thermo-anemometric sensor, 4 - measuring probe, 5 - diffuser, 6 – air channel, 7 - control computer, 8 - fan)*

Using the measurements results as the input data the values of the heat transfer coefficient were numerically calculated. The calculations were conducted for the recurrent segment of the considered heat exchanger using the Fluent CFD. The exemplary calculation results for different values of velocity and inlet temperature of air are shown in Fig. 2.

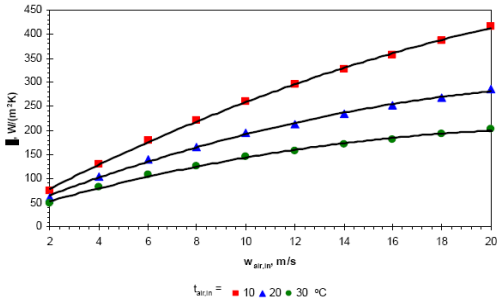

Fig. 2. *Dependence of the heat transfer coefficient versus the air velocity at the inlet of heat exchanger (Fluent calculation results)*

The measurement and numerical results shown above were then used as the input data in own computer code named HEWES for determination of overall heat transfer in the considered heat exchanger. The outcomes of this calculations were compared with heat transfer estimated on the basis on measurement of the water enthalpy drop in the considered heat exchanger (the hot water supply module).

For additional validation of the numerical results the infrared thermography was applied. The thermographic measurements have been done using ThermaCAM SC2000 camera. The aim of these measurements was to get data for comparison of numerically determined distribution of temperature at the outlet of the exchanger. First measurements have been done with perpendicular arrangement of the camera in respect to the investigated surface, and they shown almost even distribution field of the temperature.

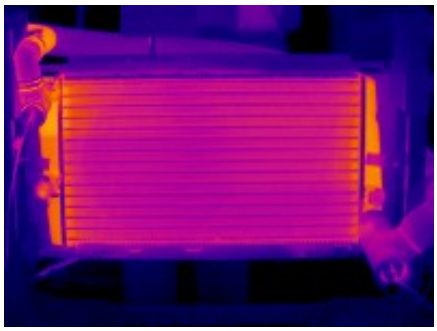

Fig. 3. *Distribution of temperature at the outlet of the heat exchanger – exemplary results*

Because these results can not be interpreted unambiguously they were not used for validation. The further infrared thermography measurements have been done with using different arrangements of the camera. The best results were obtained using sharp angle arrangements. The most measurements have been also realized with additional disturbance inserted in front of the exchanger in form of a diaphragm. The temperature field in the heat exchanger elements may be also used for evaluation of thermal tensions.

The selected results of the measurements and analyses and the most interesting final remarks and conclusions will be presented in the paper.