EPJ Web of Conferences **82**, 01060 (2015)
DOI: 10.1051/epjconf/20158201060

Thermographic study of gas flows

S.L. Elistratov and E.Yu. Slesareva

Kutateladze Institute of Thermophysics SB RAS, Novosibirsk, Russia

Abstract. To visualize the temperature field, thin threads and nets with different heat conductivity were located directly at the outlet or at some distance from the channel. This method allows to investigate fields of temperatures for diagnostics of streams of gas in channels of the modern heat exchangers and reactors.

Information about local profiles of the gas flow temperature at the device outlet is of a particular interest for analysis of operation efficiency of the modern heat exchangers and multichannel reactors with complex geometry of the long channels. For these purposes, the improved thermal-vision methods with a net – thermal detector can be used in some cases as an alternative as well as an addition to the conventional thermocouple measurements [1].

To visualize the temperature field, thin threads and nets with different heat conductivity were located directly at the outlet or at some distance from the channel; they played the role of indicators of non-isothermality of the gas flow (see Fig. 1). Their thermal images, obtained by the thermal-vision technique (see Fig. 2), allow us to estimate the efficiency of moving gas heating or cooling both in the separate channels and over the cross-section of the whole heat exchanger.

It can be seen that the reaction between the gas flow and nets allows obtaining sufficiently clear thermograms within narrow, about few degrees, temperature ranges of the gas flow and channel walls. The level of resolution for determination of local and integral temperatures on these surfaces depends on the features of thermal imaging equipment, in particular, wavelength of perceived thermal radiation and optics resolution, geometric dimensions and spectral characteristics of the net material. In application to the multi-channel assemblies, this method allows the conclusions about a degree of non-uniformity of heating or cooling inside its separate elements based on the analysis of thermograms at the outlet of reactor channels. These deviations can be caused by disadvantages in hydraulic calculation of the reactor.

One of the problems of quantitative analysis of thermal images is the right choice of emissivity degree for net or separate threads, which serve as the indicators of gas flow temperature. This parameter was determined during special experiments (see. Figs. 3, 4) through comparison of the readings of thermocouples and obtained thermograms under the same thermal conditions. Obtained at different stabilized net temperatures, these thermograms gave the setting quantitative values of this parameter for different nets and threads.

Due to thermogram processing by the applied MikroSpec program (see Figs. 5, 6) with consideration of experimental values of net emissivity, we have obtained the quantitative dependences of the local

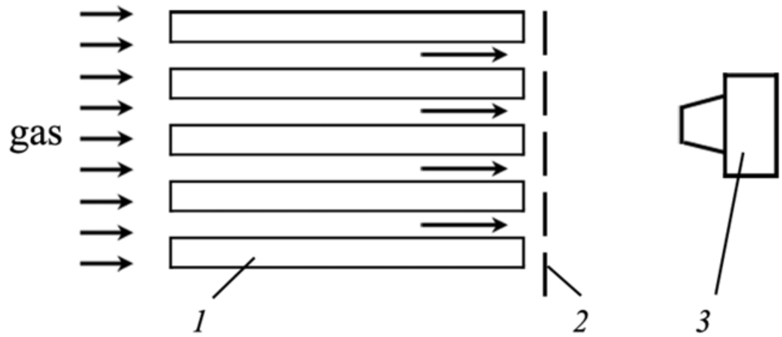

Figure 1. Schematic diagram of measurements. 1 – heat generating or heat absorbing unit; 2 – net; 3 – thermal imager.

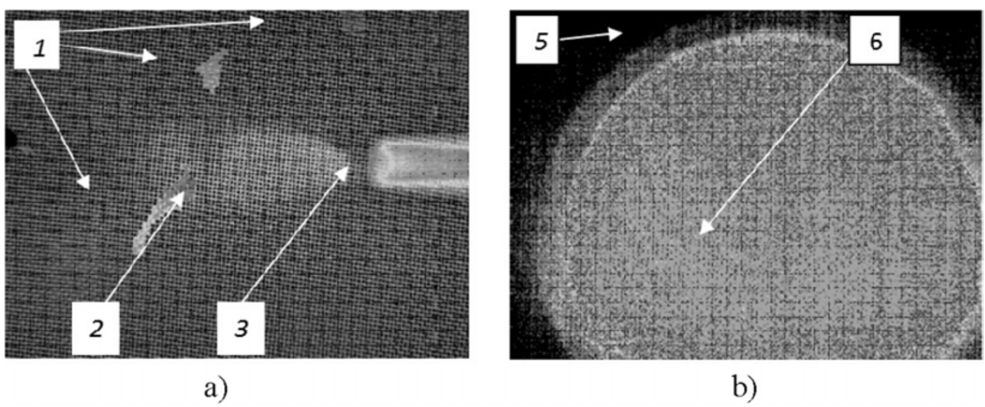

Figure 2. Thermograms of the surface of small-cell brass nets: a) thermogram of a heat wake under the action of a directed heat flux of wet air: 1 – droplets of water condensate; 2 – heat wake of the air flow; 3 – polyethylene tube with the inner diameter of 3 mm, inclined at 60° relative to the brass surface; b) thermogram of a net, tightly pressed to the outlet edge of not-heated quartz tube with the diameter of 25 mm: 5 – quartz tube wall; 6 – zone of wall heating by the flow of warm dry air.

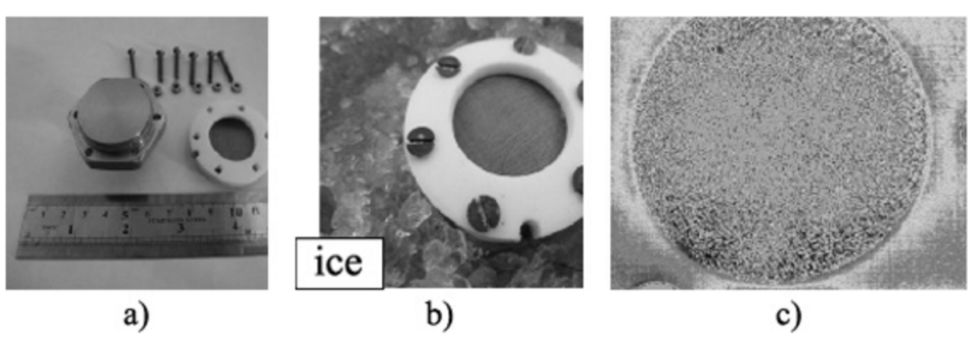

Figure 3. Main elements of the measuring cell for determination of net surface emissivity (a and b) and net thermogram at 0.0 °C (c).

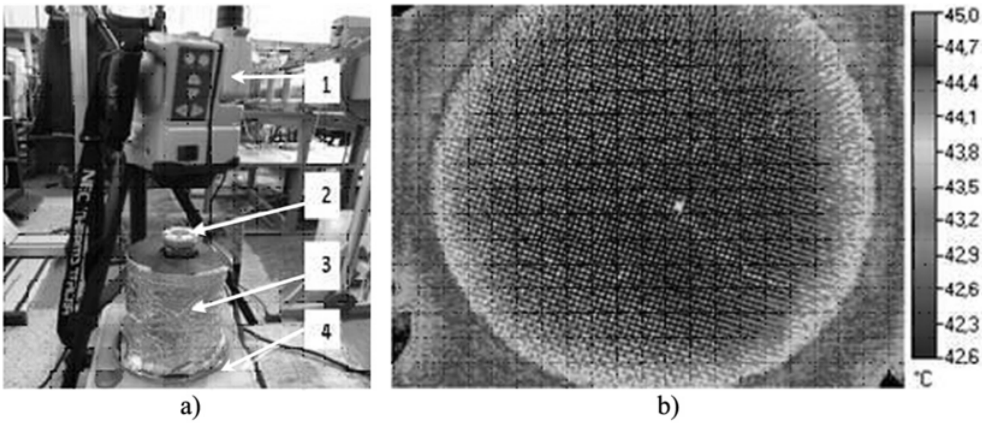

Figure 4. General view of setup (a) for determination of wall emissivity and net thermogram (b) with a thermocouple located below it: 1 – thermal imager TermoTracer TH 7102 MX/WX/MV/WV/WL with the wavelength of 10.6 μm; 2 – measuring cell with a thermocouple under the net; 3 – copper solid cylinder; 4 – electric heater with stabilization of heating temperature.

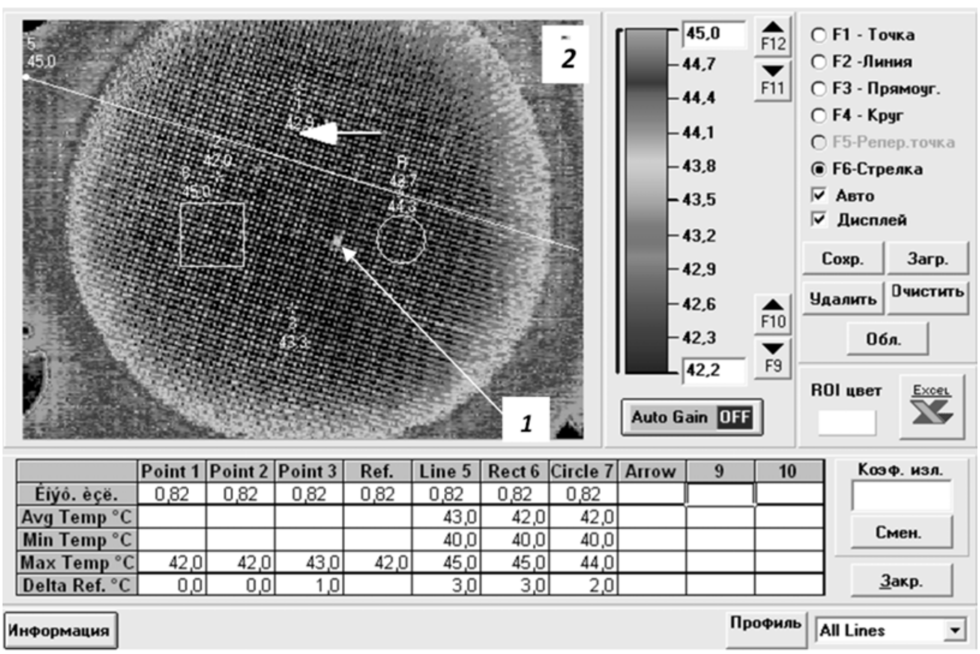

Figure 5. Methods of thermogram processing by the applied MikroSpec program: 1 – junction of thermocouple, located under the net; 2 – teflon plate.

temperature distribution. Within the accuracy of thermal-imaging measurements, these results coincided with data of thermocouple measurements.

These studies allowed the conclusion about the prospects of application of the thermal-imaging measurement methods with a net – thermal detector for diagnosis of the gas flows in the modern channel heat exchangers and reactors.

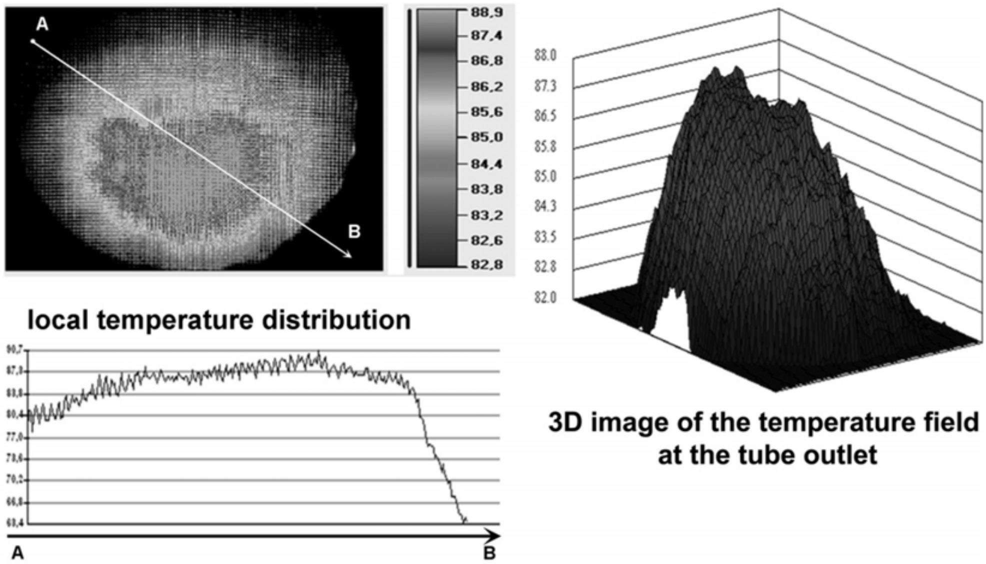

Figure 6. Thermogram of the air flow at low Reynolds numbers ($Re \leq 2000$) at the outlet of the round tube.

Reference

[1] A.V. Efimova, A.V. Zaitsev, B.P. Zhilkin, D.N. Tokarev, K.V. Zaitsev, Kh. Dashpuntsag, Bulletin of USTU: Thermal Engineering **33** (3), 139 (2004)