ANDREJ KAPJOR[1]
HELENA SMATANOVÁ[2]
JOZEF HUŽVÁR[3]
TOMÁŠ GREŠŠÁK[4]
JOZEF JANDAČKA[5]

University of Zilina, Slovakia

[1]andrej.kapjor@fstroj.uniza.sk
[2]helena.smatanova@fstroj.uniza.sk
[3]jozefhuzvar@gmail.com
[4]tomas.gressak@fstroj.uniza.sk
[5]jozef.jandacka@fstroj.uniza.sk

OPTIMIZATION OF HEAT TRANSFER ORIENTED SURFACES BY THERMOVISION AND USING CFD METHOD

Abstract

The paper presents applications of infrared measurements. It discusses the use of thermovision and CFD method in the analysis of heat transfer in experimental measurement with natural convection.

Keywords: heat transfer, natural convection, CFD method

1. Introduction

Infrared technology used to be an expensive testing method, nevertheless, today even small firms may buy simple IR equipment. The application ranges from heat losses determination in buildings (it is quite widespread due to the thermal performance analysis) to complex scientific measurements. The fundamental idea of the infrared technique is the radiation detection. Its intensity in the simplest form may be calculated with the Stefan – Bolzmann law. This radiation is comes from every body of temperature above zero Kelvin and depends on the temperature of the object to the forth order, emissivity (0 to 1) and the Stefan – Boltzmann's constant ($\sigma = 5{,}67 \times 10^{-8}\ W/(m^2K^4)$). During testing the detector obtains radiation coming from other sources too (not just from the observed element). As a result, correct calculation of temperature values requires consideration of other sources of radiation (radiation reflected from the element and emitted from some other sources in the surroundings as well as atmospheric radiation). This is done by the software of an IR system as data such as temperature of the things located in the vicinity, atmosphere, air humidity and other are input into the system [3, 4].

2. Examples of the measurements

2.1. Heat transfer from floor convector to surroundings

To recognise a mechanism of heat transfer from floor convector to surroundings by natural convection it is good to know the shape of flow and temperature distribution near the surface.

In our case the thermovision was used to visualize the heat output from the convector. It is known that by the help of the thermovision it is possible to visualize also small temperature differences. But the object must not be diathermal and the emission coefficient of its surface should be close to 0,9 because the air close to the surface of the floor convector heated through the natural convection is also diathermal, so it is invisible on the infra screenshots. From this reason the method of the heating of a thin, most often paper, foil was used for the visualization. The foil was placed at the surface so that the orientation of its surface was along the air streaming and so that it does not influence the natural convection. The foil is heated by the streaming warm air on temperatures close to the streaming air and the temperature profile in the closeness of the object is well visible as well as quantifiable. The way of placing the foil for the visualization in the thermostatic chamber is shown in Figure 1. The infracam MIDAS 320L was used and the pictures were evaluated by the help of the Pyrosoft software.

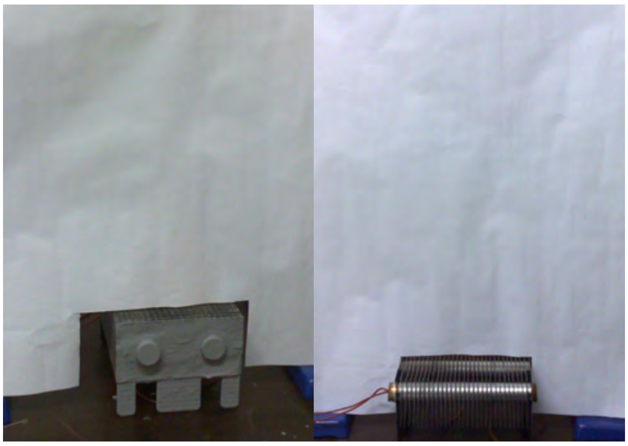

Fig. 1. The sample of floor convector in the thermostatic chamber

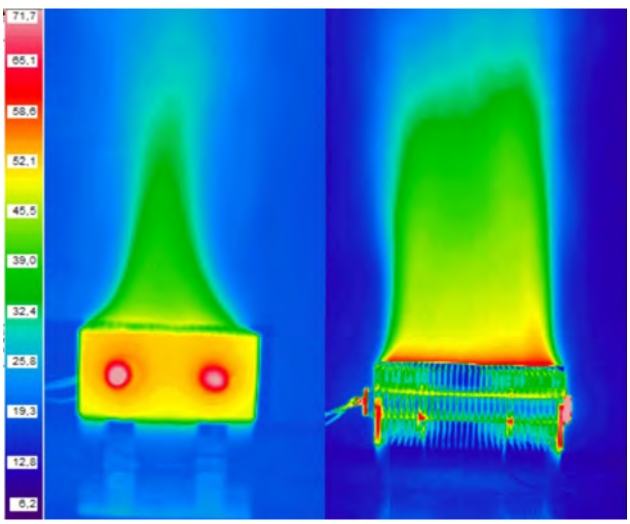

Fig. 2. Visualization of temperature fields

We also made measurements by CFD method on the same sample of floor convector as used in thermostatic chamber. The calculations were made in program Fluent. From CFD simulations in program Fluent Figures 3 and 4 were made. In Figure 3 we can see flow trajectory with velocity lines. While in Figure 4 we can see visualization of thermal field from a sample of a floor convector.

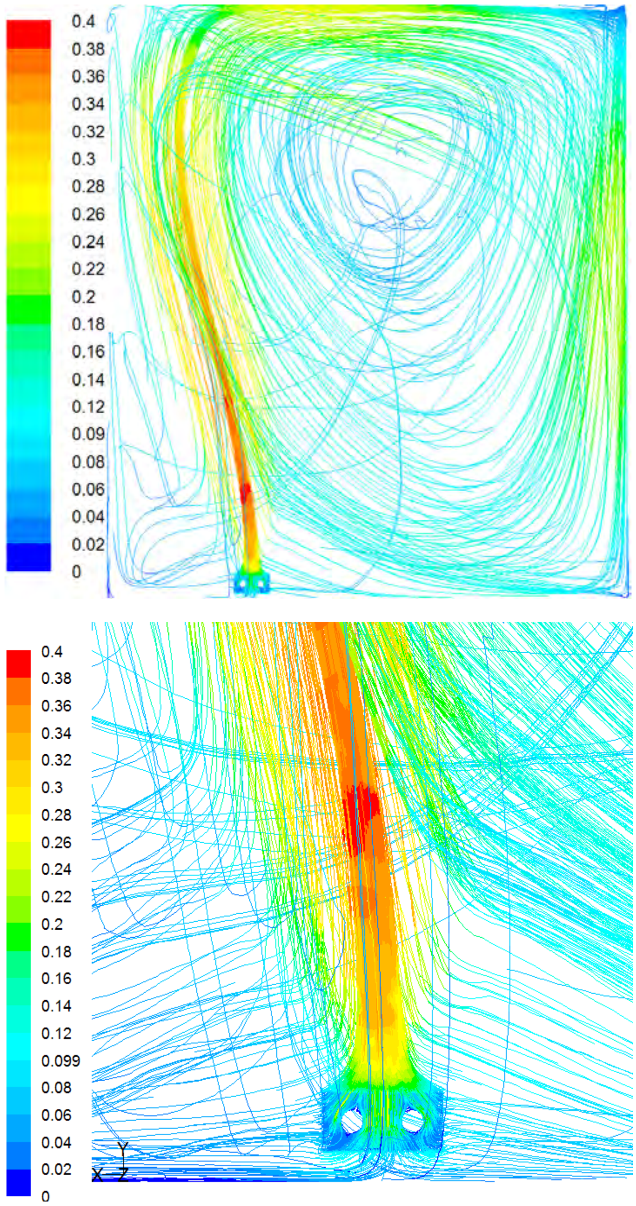

Fig. 3. Flow trajectory with velocity lines

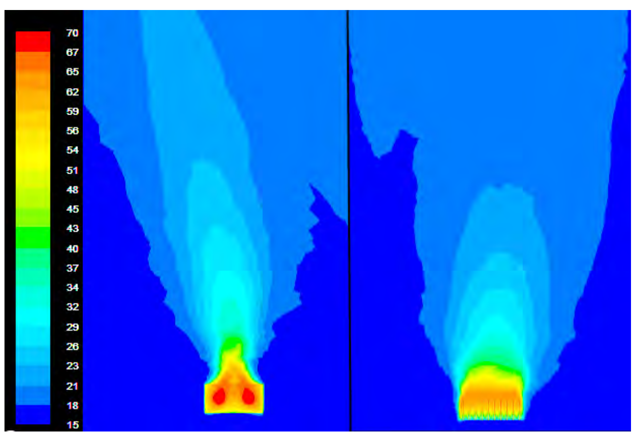

Fig. 4. Thermal field from a sample of a floor convector

2.2. Heat transfer from tubular heater

Another experimental measurement of heat transfer was made from tubular heater. Like in the previous case we compared heat transfer by CFD method and by thermovision.

The tubular heater was in thermostatic chamber as can be seen in Figure 5. Thermal gradient of tubular heater was 75/65°C and surrounding temperature was 20°C.

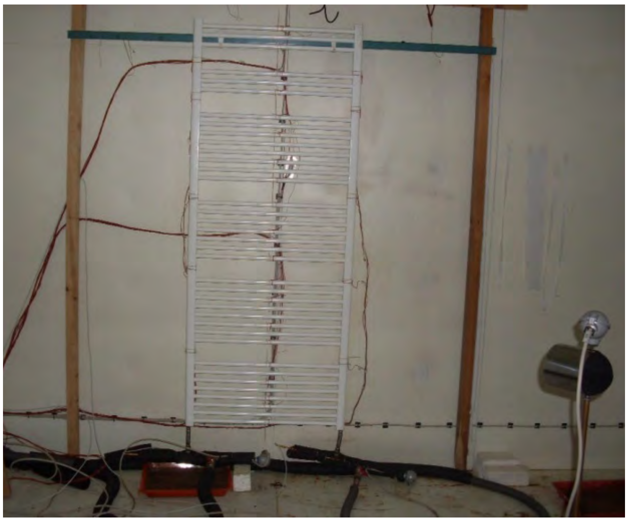

Fig. 5. Tubular heater in thermostatic chamber

When we achieved the equilibrium state (that was about 30 minutes), we made thermovision shots, which can be seen in Figure 6.

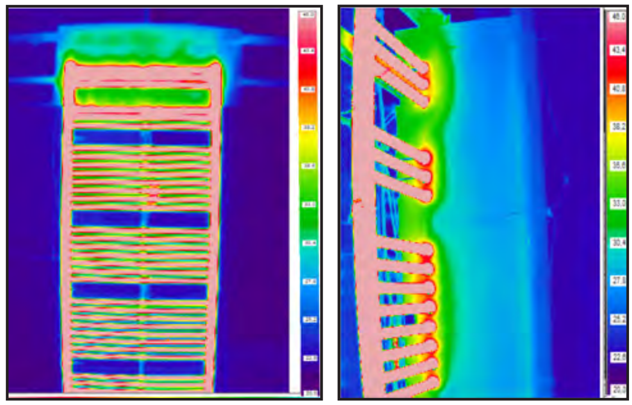

Fig. 6. Thermovision shots of tubular heater in thermostatic chamber

We also made heat transfer from tubular heater by CFD method in program Fluent. After the award of input conditions, like heating temperature, surrounding temperature and etc, the measurement started up. All of these parameters were similar as in case of measurement in thermostatic chamber. In Figure 7 screenshots of heat transfer form tubular heater by CFD method have been presented.

3. Conclusions

Infrared measurements become a widespread tool both in the industrial and science applications. The availability of IR systems caused mainly by their lower cost has enabled broader use of this method. Possible applications range from heat losses analysis

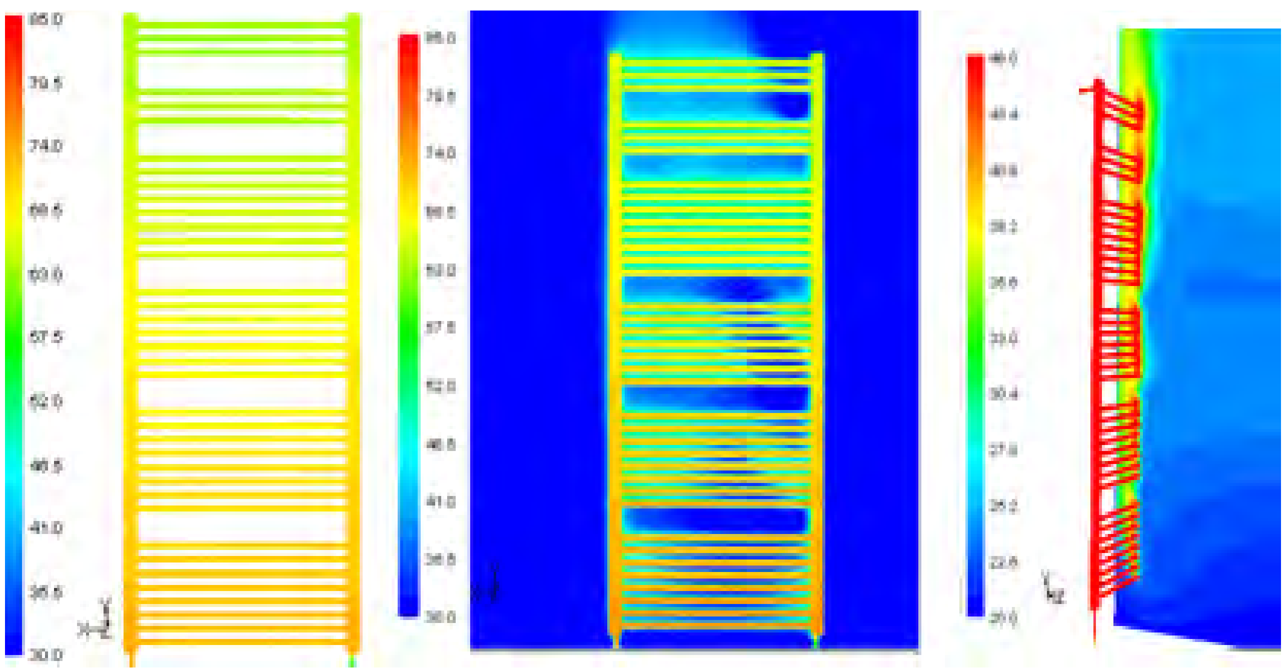

Fig. 7. Visualization of temperature fields in Fluent

in buildings (e.g. [3, 4]), heating systems [1], energy recovery systems [2] and other. The results of thermovision measurements can be compared with the calculations made in specialised computer finite element method programmes. Due to so many possible applications IR technology will surely be in even more widespread use in the future.

Acknowledgement

The research is supported by European regional development fund and Slovak state budget by the project "Research centre of University of Žilina", ITMS 26220220183.

References

[1] Lenhard R., Jandačka J., Malcho M.: *Modelovanie prestupu tepla na pasívnych chladiacich konvektoroch,* In: Vetranie a klimatizácia 2008: Energetická hospodárnosť vetrania a klimatizácie pri tvorbe vnútornej klímy : zborník prednášok z 11.

[2] Vantúch M., Jandačka J., Malcho M., Kasanický M.: *Measuring phase changes of CO_2 in a gravitational heat pipe on simulated depth borehole device,* TRANSCOM 2013 : 10-th European conference of young research and scientific workers : Žilina, June 24–26, 2013, Slovak Republic.

[3] Orman Ł.J.: *Badania termowizyjne w ocenie termoizolacyjności budynków*, Instal 4A, 2009, pp. 19–23.

[4] Orman Ł.J., Sułek M.: *Diagnostyka metodą termografii w podczerwieni w ocenie termoizolacyjności i charakterystyki energetycznej*, Proc. of Conf. "Terotechnologia 2009", pp. 325–330.

[5] Yakhot, V., Orszag, S.A., Thangam, S., Gatski, T.B., Speziale, C.G.: *Development of turbulence models for shear flows by a double expansion technique*. Physics of Fluids A 4, 1992, pp. 1510–1520.