

Measurement of temperature fields in 3D airflows using an infrared camera

Martin Pešek¹, Milan Pavelek²

¹ Brno University of Technology, Faculty of Mechanical Engineering, Energy Institute, Technická 2896/2, Brno, m.pesek@email.cz

² Brno University of Technology, Faculty of Mechanical Engineering, Energy Institute, Technická 2896/2, Brno, pavelek@fme.vutbr.cz

Abstract This article deals with the measurement of temperature fields in 3D airflows using an infrared camera and the measuring net with measuring targets. This method is based on the visualization of temperature fields on an auxiliary material (paper targets) which is inserted into the non-isothermal airflows. In the article the temperature fields are made visible by an air-heating fan, and consequently the temperature field is evaluated. The fan generates approximately a rotate-circle airstream in the axis of fan mouth outlet. The results are compared to the similar measurement the using the equipment for visualization a temperature field in 2D airflows by an infrared camera and the compact sheet of textile. This measuring method can be used in many various applications such as air-heating and air-conditioning.

1 Introduction

The infrared camera is a very effective device for a noncontact measurement of temperature fields in many scientific disciplines and industry [6]. Thermography (Infrared thermal imaging) is applied in research and development such as non-destructive testing, medical science (Fig. 1), heat transfer and thermomechanics, reducing energy costs of monitoring in civil engineering (Fig. 2), and many more. This measuring method provides a visual image records allowing obtain information for a deeper knowledge of thermal states and processes in the research object. Visualization is a technique for creating images and animations to formulate a particular argument to put the possible problem right [5].

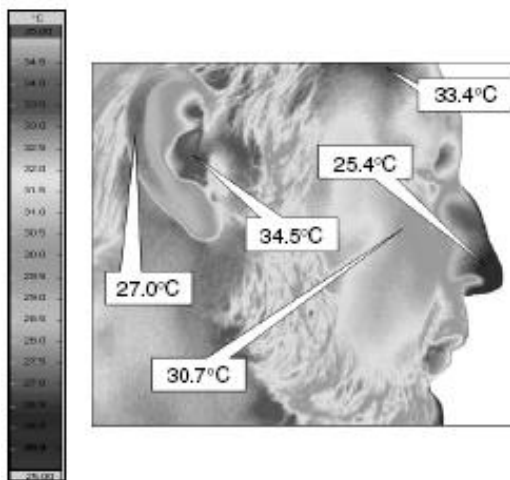


Fig. 1 The usage of an infrared camera in medical science [1]

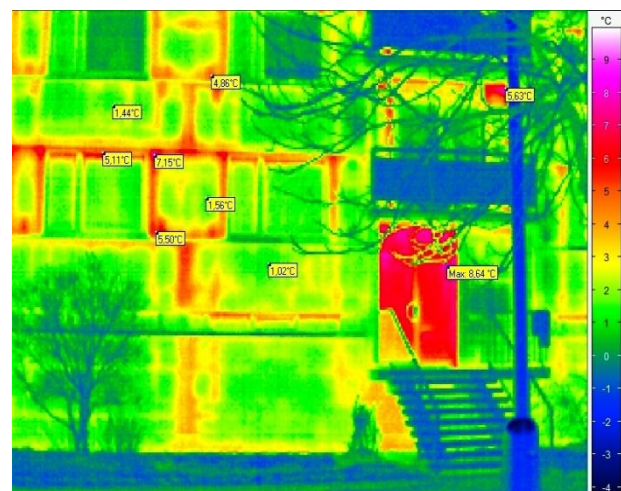


Fig. 2 The infrared monitoring in civil engineering

The thermography is being used mainly for determining surface temperatures but the described measuring method tries to explain the possibilities of monitoring and measurement temperature fields in the air. Immediate knowledge of the distribution of temperature field in the non-isothermal airflow can allow to quickly identify a possible problem in the design or equipment in an ordinary usage of air conditioning or hot-air heating. The visualization of temperature fields in the air can also detect the spatial and time context of monitored processes.

2 Description of 3D temperature field measuring method

It is well known that the air is a transparent material in infrared radiation, and therefore it is impossible to make the air temperature visible directly by the infrared camera [3]. For visualization the air temperatures the measuring targets are necessary to be used which are situated in the measuring frame that is inserted into the research area [2]. The measuring target is created as a point where the surface temperature as the air temperature is measured. For successful application of this method, the suitable material, which the measuring target was made of, was needed to choose. This material must especially have a large emissivity value and the quick response to the temperature difference (small time constant) [4]. The visualization of temperature fields in the air by the infrared camera on measuring targets is especially suitable for measuring temperature fields in 3D airflows. In notion of measuring temperature fields in 3D airflows it can be imagined the measurement where the compact auxiliary material (compact sheet) is not parallel with streamlines, or the measurement where a rotate circle airstream is generated from the fan (Fig. 3), or alternatively more heat sources are used and so one.

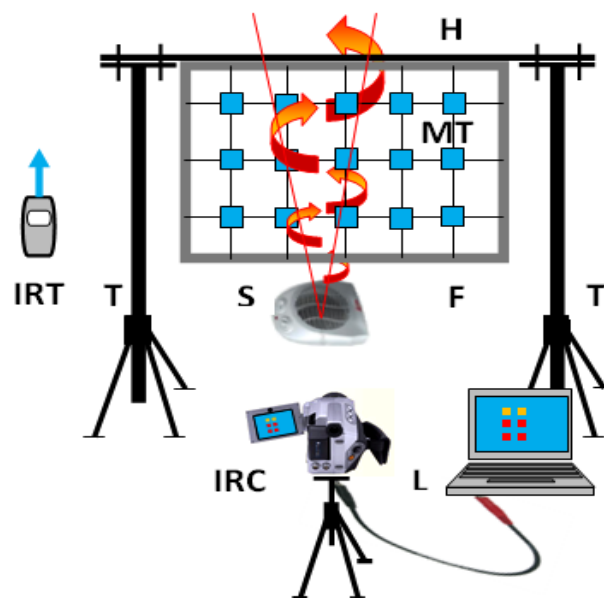


Fig. 3 The stand for measuring temperature fields in 3D airflows by the fan with a rotate circle airstream by an infrared camera. IRC – Infrared Camera, L - Laptop, MT – Measuring Targets, T - Tripod, H - Holder, IRT – Infrared Thermometer, S – Source of 3D Non-Isothermal Airstream, F - Frame

The fan produces the hot airflow as convective heat transfer to the surface of measuring targets that changes their surface temperatures which are measured as an air temperature by the infrared camera. The device shows the temperature field on measuring targets *MT* from heat sources *S* using the infrared camera VarioCam *IRC* linked to laptop *L*. At the same time the

radiating temperature is measured in the measuring area by the infrared thermometer Testo *IRT*. The frame of square net with measuring targets is attached to the holder *H* to the height-adjustable tripod stand *T* (Fig. 3).

3 The experiment of temperature field in 3D airflows measuring

For the following experiment the hot-air rotation fan was chosen. The rotation airstream by this fan is generated, and therefore it is necessary to use an auxiliary material for the 3D airstream visibility on which is possible to measure temperature field. The photo from this experiment and the air-stream visualization of this fan are shown in Fig. 4 and Fig. 5.



Fig. 4 The equipment for measuring temperature fields in 3D airstream

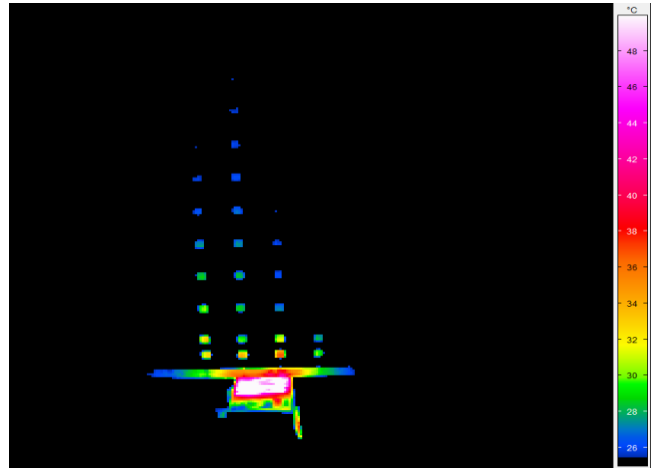


Fig. 5 The original thermogram of 3D airstream measuring

4 The temperature field in 3D airflows evaluation

If it is not evident that a 3D airstream from this device has to be visualized, the device for measuring temperature field in 3D airstream could be wrongly used (Fig. 6).

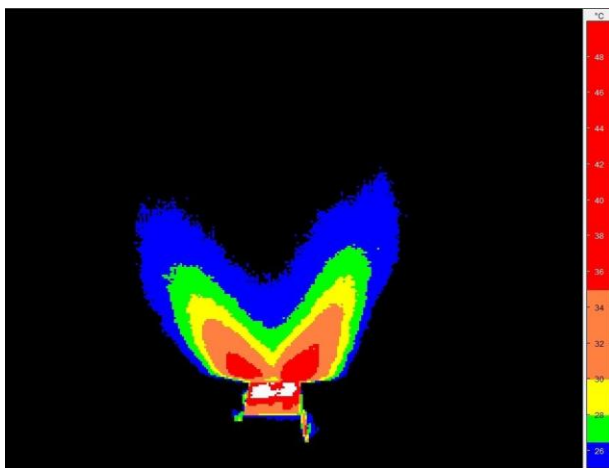


Fig. 6 The wrong visualization of temperature field in 3D airstream using a compact sheet of auxiliary material and the infrared camera

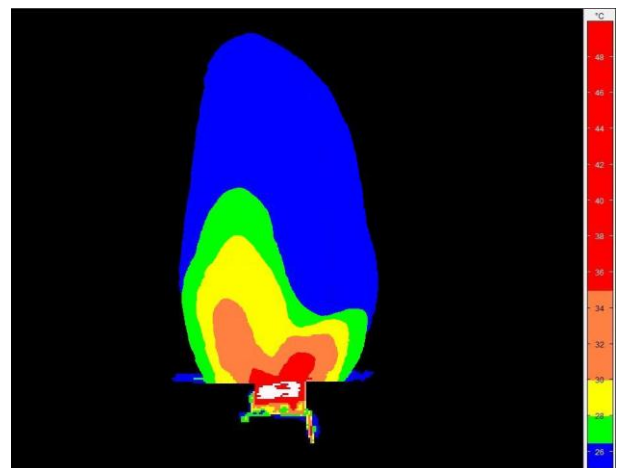


Fig. 7 The correct visualization of temperature field in 3D airstream using measuring targets and the infrared camera after software adjustment

The equipment for the measurement of temperature fields in 2D airflows is easily mobile and it immediately gives accurate information about the temperature field while the device



for measuring temperature field in 3D airflows is uneasy transferable. The area between the measuring targets must be software adapted (Fig. 7) to produce a complete thermogram which could be comparable to the thermogram from device of measuring the temperature field in 2D airflows.

5 Discussion

In Fig. 6 and in Fig. 7 there is evidently shown that when the device for measuring temperature fields in 2D airflows for 3D airstream is used (e.g. it is not obvious at the first sight that it is a 3D airstream), the influence of the airflow distribution on compact sheet of support material has a significant effect on temperature field (Fig. 6) which is shown on the compact auxiliary material by infrared camera. The equipment for temperature fields in 3D airflows can also be used for measuring 2D non-isothermal airstreams but the resulting thermogram does not properly show an illustrative figure of temperature field (Fig. 5) as the temperature field which is visualized on compact sheet of auxiliary material (Fig. 6). The question is the number of measuring targets in measuring net for 3D specific airflows that the most efficient temperature field could be displayed without the complicated software editing. It is necessary to respond this question in next research of measuring temperature field in 3D airflows.

6 Conclusion

The measuring of temperature fields in the air by infrared camera is one of the possible methods how to measure the temperature fields in the air. This method was described to visualise the temperature field in a heated 3D airflow by using an IR camera. The method was compared with measuring by the equipment for temperature fields in 2D airflows and temperature fields in 3D flows. From the shown experiment is demonstrable that the usage of a spacious sheet of material is suitable only for two dimensional airstreams and for three dimensional airstreams the measuring net is needed to use.

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