Comparison of Infrared and Background Oriented Schlieren Techniques for Air Flow Temperature Measurements

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HIGHLIGHTS

• 2D air temperature fields over a horizontal heated plate are obtained with BOS and two infrared imaging techniques.
• Infrared techniques include thermography of solid targets installed within the flow and observation of a uniform screen through the air flow.
• Quantitative visualization results are compared to 2D and 3D simulations and to thermocouple measurements.
• Temperature measurements using solid targets thermography are shown to be affected by reflected radiation of the plate.
• Observation of uniform screen through the flow with proposed post-processing is shown to be simple and reliable non-intrusive technique.

ABSTRACT

Air flow temperature measurements for natural convection over a horizontal heated plate using Background Oriented Schlieren and two quantitative infrared imaging techniques are performed to compare the accuracy, spatial resolution and simplicity of implementation. The first infrared technique, which can be called infrared thermography of optically thin media, is based on observation of a distant screen with known temperature through the investigated air flow. Due to high sensitivity of modern infrared cameras, it is possible to measure changes in observed radiation associated with air flow temperature variations without addition of absorbing gas. This allows obtaining 2D temperature fields averaged along line-of-sight, analogous to quantitative schlieren or interferometry techniques, using only software supplied with infrared camera. The second technique, becoming increasingly popular in engineering practice, employs solid targets installed within the air flow and observed with infrared camera. Temperature distributions, obtained with both infrared techniques, are compared to each other, to measurements using Background Oriented Schlieren, to thermocouple measurements and to results of 2D and 3D numerical simulations. It is shown that solid target apparent temperature is affected by radiative heat exchange with the heated plate. Simultaneous use of three kinds of targets with special treatment is proposed to determine local values of reflected radiation contribution and to correct for this effect. Infrared thermography of optically thin media is shown to be simple and reliable non-intrusive technique for air flow temperature measurements, possessing high spatial resolution. However, its random error is increasing with transmissivity of the flow under study.