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VISUALIZATION OF SPATIO-TEMPORAL HEAT TRANSFER TO A TURBULENT FLOW

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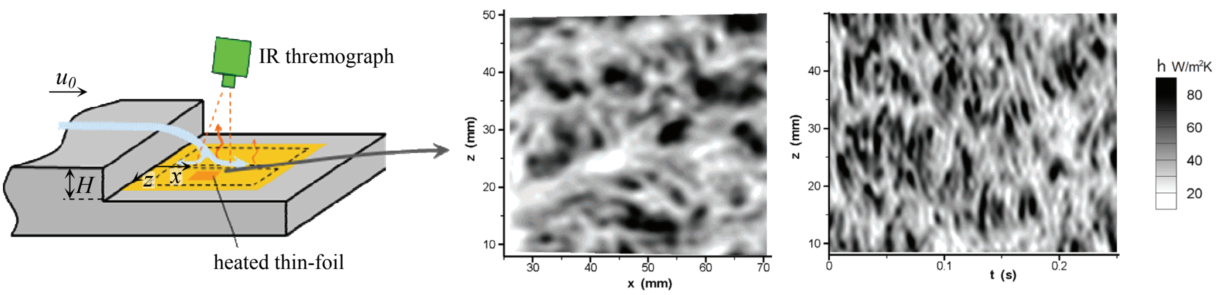
Fluid: low-speed air flow
Visualization method(s): infrared thermography, heated thin-foil
Other keywords: spatio-temporal measurement

ABSTRACT: Convective heat transfer is, by nature, generally nonuniform and unsteady, a fact reflected by flow turbulence. However, most experimental studies concerning turbulent heat transfer have been performed in a time-averaged manner or using one-point measurements due to difficulties in the spatio-temporal measurements. This frequently results in poor understanding of the heat transfer mechanisms.

The recent improvement of infrared thermograph with respect to temporal, spatial and temperature resolutions enable us to investigate instantaneous temperature distribution and its fluctuating pattern on a solid surface caused by flow turbulence[(1)-(3)]. Although the thermo-images contain considerable attenuation in time and space due to thermal inertia and diffusion on the solid wall, it is possible to estimate quantitative heat transfer if the attenuation can be restored. In this paper, the procedure to estimate the quantitative heat transfer is presented, which includes filters (median and low-pass filters) to reduce measurement noise and inverse heat conduction analysis inside the test surface. As a result, the spatio-temporal heat transfer was successfully visualized up to 250 Hz in time and about 2 mm in space for a low-velocity air-flow (up to 6 m/s) by employing a heated thin-foil (2 μm thick titanium foil) and a high-performance thermograph (frame rate of 1000 Hz and NETD of about 0.02 K). Some results obtained recently will be presented for the turbulent boundary layer and for the separated and reattaching flow, as shown in Fig. 1.



Schematic of experimental setup — Instantaneous distribution — Spanwise time trace at $x/H = 5$

Fig. 1 Time-spatial distribution of heat transfer coefficient around the flow reattaching region behind a backward-facing step ($H = 10$ mm, $u_0 = 6$ m/s, $Re_H = 3800$)

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