

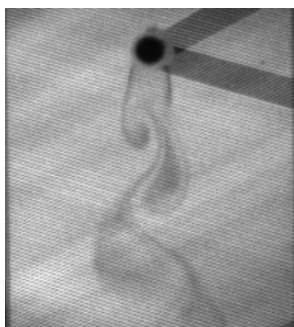
A Novel Molecular Tagging Technique for Simultaneous Measurements of Flow Velocity and Temperature Fields

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(a) Grid image 0.5 ms after the laser excitation pulse.



(b) Same grid 5 ms later.

Fig. 1.

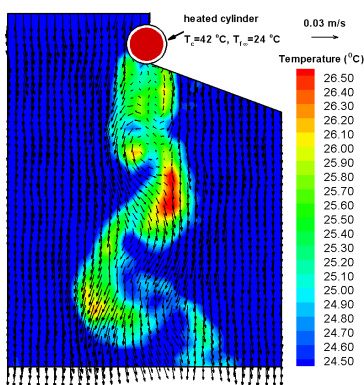


Fig. 2. Simultaneous velocity and temperature fields derived from the image pair shown in Fig. 1.

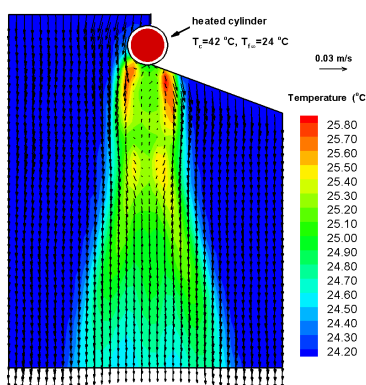


Fig. 3. Ensemble-averaged velocity and temperature fields.

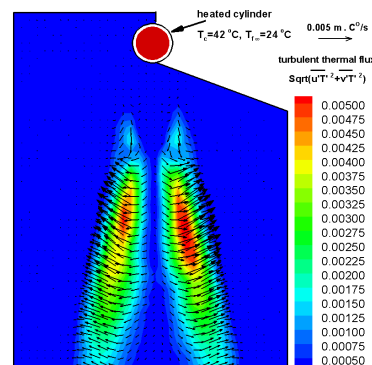


Fig. 4. Measured turbulent thermal flux vectors.

A novel molecule-based flow diagnostic technique, called molecular tagging velocimetry and thermometry (MTV&T), has been developed recently to achieve simultaneous measurements of flow velocity and temperature distributions. For the MTV&T measurements, pulsed laser beams are used to tag phosphorescent tracer molecules premixed in the working flow. The tracer molecules will give off long-lifetime phosphorescence emission, serving as glowing markers for the flow measurements. The movements of the glowing molecules are imaged twice after the same laser pulse. The measured Lagrangian displacements of the tagged molecules between the two interrogations provide the estimates of velocity vectors. Simultaneous temperature measurement is achieved by taking advantage of the temperature dependence of phosphorescence lifetime, which is estimated from the phosphorescence intensity ratio of the two interrogations. An example of the MTV&T measurements taken from a study of the thermal effect on the wake instability behind a heated cylinder is shown here. The molecular tracers are tagged by pulsed multiple laser beams in a grid pattern. Both the initially tagged regions and their subsequent evolution 5 ms later are shown in Fig. 1, along with the resulting simultaneous velocity and temperature distributions derived from the image pair (Fig. 2). Since the instantaneous velocity and temperature distributions are measured simultaneously, ensemble-averaged velocity and temperature fields (Fig. 3) as well as the turbulent thermal flux vectors (Fig. 4), i.e., the correlation between the velocity and temperature fluctuations, can also be derived from the measurements.