Investigations of Flow Patterns in Ventilated Rooms Using Particle Image Velocimetry

Applications in a Scaled Room with Rapidly Varying Inflow and over a Wall-Mounted Radiator

av

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ABSTRACT

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This thesis introduces and describes a new experimental setup for examining the effects of pulsating inflow to a ventilated enclosure. The study aimed to test the hypothesis that a pulsating inflow has potential to improve ventilation quality by reducing the stagnation zones through enhanced mixing. The experimental setup, which was a small-scale, two-dimensional (2D), water-filled room model, was successfully designed and manufactured to be able to capture two-dimensional velocity vectors of the entire field using Particle Image Velocimetry (PIV). Using in-house software, it was possible to conclude that for an increase in pulsation frequency or alternatively in the flow rate, the stagnation zones were reduced in size, the distribution of vortices became more homogeneous over the considered domain, and the number of vortices in all scales had increased. Considering the occupied region, the stagnation zones were moved away in a favorable direction from a mixing point of view. In addition, statistical analysis unveiled that in the far-field occupied region of the room model, stronger eddies were developed that we could expect to give rise to improved mixing. As a fundamental experimental study performed in a 2D, small-scale room model with water as operating fluid, we can logically conclude that the positive effect of enhanced mixing through increasing the flow rate could equally be accomplished through applying a pulsating inflow.

In addition, this thesis introduces and describes an experimental setup for study of air flow over a wall-mounted radiator in a mockup of a real room, which has been successfully designed and manufactured. In this experimental study, the airflow over an electric radiator without forced convection, a common room-heating technique, was measured and visualized using the 2D PIV technique. Surface blackening due to particle deposition calls for monitoring in detail the local climate over a heating radiator. One mechanism causing particle deposition is turbophoresis, which occurs when the flow is turbulent. Because turbulence plays a role in particle deposition, it is important to identify where the laminar flow over radiator becomes turbulent. The results from several visualization techniques and PIV measurements indicated that for a room with typical radiator heating, the flow over the radiator became agitated after a dimensionless length, 5.0–6.25, based on the radiator thickness.

Surface properties are among the influencing factors in particle deposition; therefore, the geometrical properties of different finishing techniques were investigated experimentally using a structured light 3D scanner that revealed differences in roughness among different surface finishing techniques. To investigate the resistance to airflow along the surface and the turbulence generated by the surfaces, we recorded the boundary layer flow over the surfaces in a special flow rig, which revealed that the types of surface finishing methods differed very little in their resistance and therefore their influence on the deposition velocity is probably small.

Keywords: Particle Image Velocimetry (PIV), experimental study, structured light 3D scanning system, ventilation, varying flow rate, room model, wall-mounted radiator, air, water, flow, Particle Image Velocimetry (PIV), experimentell studie, scanningsystem för strukturerat 3D-ljus, ventilation, varierande tilluftsflöde, rumsmodell, väggmonterad radiator

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