Determination of multiple unknown heating sources from the given pedestrian thermal comforts

Background

Built microclimate not only greatly influences the overall energy consumptions of buildings, but also directly affects the health of human beings. It is well known that the air flows, thermal and pollutant dispersions within the building clusters and indoors could be predicted by the computational fluid dynamics (CFD), which could be found in many recent publications and researches.

In the context, methodology of inverse CFD will be implemented and it could design the air flows, thermal and pollutant dispersions depending on the requirements of occupants' thermal comfort [1, 2]. Additionally, with the emergence of terrorist attacks and epidemic propagation of airborne pollutants (SARS, TB or influenza virus), the harmful sources around and within the buildings should be tracked to avoid their further threats to the pedestrians and residents.

Two solution methodologies, function-based inverse CFD and probability-based inverse CFD have been developed respectively for the inverse design of built air environment design and inverse identification of harmful sources [1, 2].

Problem definition

As the preliminary investigations, steady air environment within and around two building blocks will be concerned, wall thermal conductions and solar radiations will be simultaneously involved.

During the calculations of thermal convective flows and solar radiation and long wave thermal radiations between walls, the thermal flux balances on the wall interfaces will be employed to couple the thermal flows in different modes, convection, conduction and radiation.

Air temperatures in the pedestrian level in the street canyons, $T(\boldsymbol{\xi})$, will be firstly given according with the usual thermal comfort of pedestrians. These given temperatures will subsequently be fed into the procedures of function-based inverse CFD (here, conjugate gradient method is implemented). After the inverse CFD simulations, one can identify three heating sources sparse-discretely distributed within the two building enclosures with natural ventilation ports. For simplification, these heating sources will be of the continuous functional forms $Q_1(\boldsymbol{\xi}_1)$, $Q_2(\boldsymbol{\xi}_2)$, and $Q_3(\boldsymbol{\xi}_3)$, where $\boldsymbol{\xi}_i$ represents the spatial coordinate units.

The effects of flow patterns, solar radiation, and wall materials on the inverse solutions will be investigated in details.

Programming languages FORTRAN, C or MATLAB are recommended for the procedure developments, particularly concerning the programming the solution procedures of Direct, Sensitivity, and Adjoint problems required by conjugate gradient method. The software TECPLOT will be employed for the post-process of

numerical data. For preliminary researchers, commercial software Fluent or OpenFOAM could be recommended.

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References

[1] Fu-Yun Zhao, et al. Determining boundary heat flux profiles in an enclosure containing solid conducting block. International Journal of Heat and Mass Transfer 53 (2010) 1269-1282.
[2] Di Liu, Fu-Yun Zhao, Han-Qing Wang. History recovery and source identification of multiple gaseous contaminants releasing with thermal effects in an indoor environment. International Journal of Heat and Mass Transfer 55 (2012) 422-435.