

FLOW AND DISPERSION IN THE PRESENCE OF SURFACE-MOUNTED CUBES

Elżbieta Moryń-Kucharczyk¹, Renata Gnatowska²

¹Institute of Thermal Machinery, Czestochowa University of Technology, Poland;

²Institute of Thermal Machinery, Czestochowa University of Technology, Poland;

E-mail: moryn@imc.pcz.czest.pl

Key words: dispersion in atmospheric boundary layer, experimental and numerical modeling

The wind ground layer structure is an important factor influencing the climate and health in built-up areas, determining the strength and natural ventilation of constructions and affecting the dispersion processes. The propagation of pollutants around wind engineering structures, governed by convection and diffusion mechanism and depends strongly on the local velocity field (Moryn-Kucharczyk et al., 2007). To understand the phenomena related to the forming of concentration fields it is necessary to recognize the local features of the flow in built-up areas with the special emphasize for the mean velocity direction, random fluctuations and periodical oscillations accompanying an vortex generation in bodies neighborhood.

The paper presents and discusses the results of the complex research program aimed at understanding a character of the flow field in vicinity of bluff-bodies immersed in a boundary layer, as an important element of unsteady phenomena generated in the ground-level zone and forming processes of pollutant dispersion. The experimental modeling of the flow around the body arrangement and the mean concentration profiles of tracer gas (CO₂) was supported and extended with numerical simulations performed with the use of the commercial CFD code (FLUENT). During experimental and numerical model testing of environmental aerodynamics, actual shapes of ground object are typically replaced with their simplified versions.

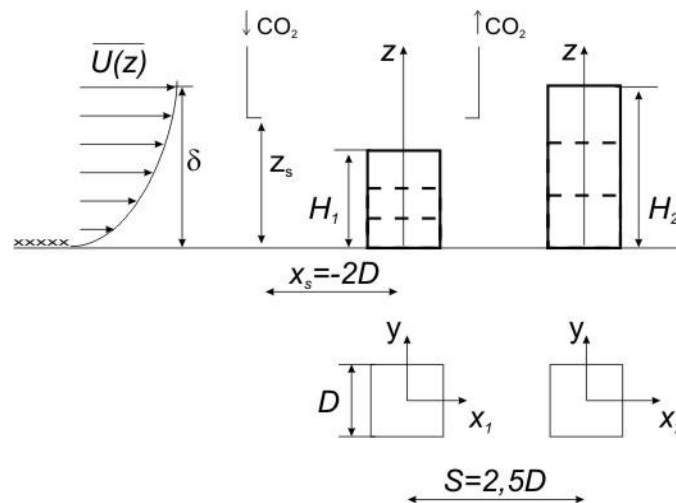


Figure 1: Schematic presentation of the set-up and nomenclature

The analysis has been performed for the simple example of inline arrangement of two surface-mounted square cylinders arranged in tandem $H_1/H_2 = 0,6$, for different location of

emission source (see Fig. 1). The source of emission of carbon dioxide used as a tracer gas during the investigations was located before the windward object.

Analysis of gas pollutants dispersion process requires in-depth identification of the structure of flow around the buildings. The flow structure around three-dimensional bluff-body located on the surface with formed boundary layer is characterized by a high level of complexity (Gnatowska et al., 2009). The case under consideration in this work concerns tandem arrangement which is characterized by H_1/H_2 parameter, which is conducive to occurrence of so-called "downwash" effect $H_1/H_2=0,6$. This effect consists in washing of front side of the leeward object with large air masses, which results in strong air circulation in the area between objects, which determines flow structure between them.

The observed modifying impact of interaction between the objects in tandem arrangement is reflected in the results of measurements of concentration of the tracer gas emitted in their environment (Gnatowska, 2011). The aim of this work was to determine the impact of objects configuration, their degree of "immersion" in the boundary layer and location of emission source for the spread of the tracer gas emitted in the vicinity of two rectangular blocks in tandem arrangement. Such studies may contribute to the better understanding of physical processes and provide necessary information for the development of numerical modeling.

Acknowledgement

The computations were performed at Academic Computer Centre CYFRONET AGH in Cracow (grant No. MNiSW/SGI3700/PCzest./024/2009), which we gratefully acknowledge. The investigations presented in this paper have been obtained within the project No. BS/MN-1-103-301/11/P "Modeling of flow phenomena and wind comfort in built-up areas".

References

- Gnatowska R. (2011): *Numerical modeling of pollutant dispersion in flow around the objects in tandem arrangement*. Numeryczne modelowanie rozprzestrzeniania się zanieczyszczeń gazowych wokół obiektów w konfiguracji tandem. Proceedings of ECOpole, Vol. 5, No. 1. pp.35-39
- Gnatowska R., Moryn-Kucharczyk E. (2009): *Wind tunnel modelling of pollutant dispersion around surface-mounted cubes in tandem arrangement*, Proc. 3rd IC-EpsMsO 3rd International Conferences on Experiments / Process / System Modelling / Simulation & Optimization, Ed. Demos T. Tsahalis, Athens, pp. 774-780
- Moryn-Kucharczyk E., Gnatowska R. (2007): *Pollutant dispersion in flow around bluff bodies arrangement*, Wind Energy, Springer Verlag Berlin Heidelberg, pp. 49 – 53