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ORIGINAL PAPER

CFD-based atmospheric dispersion modeling in real urban environments

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The process of CFD model application for atmospheric dispersion modeling is presented. Increasing the CPU power opens new possibilities of the CFD approach application for consequence analysis in real complex urban environments. As successful CFD simulation is directly dependent on the quality and complexity of the computational mesh, a new methodology of transferring the Geographic Information System (GIS) data to the computational mesh can be utilized. A user software for importing and manipulation with the GIS data and their subsequent transfer to an instructional file for the generation of the computational mesh was prepared and tested. The introduced methodology is relatively simple and it requires only a small amount of input data. The process of creating a computational mesh is very straightforward and fast, which enables the application of CFD modeling in urban environments in all fields of engineering applications in safety analysis. Several recommendations concerning proper definition of boundary conditions for atmospheric dispersion modeling were summarized. The presented approach was tested on a realistic case study of liquefied chlorine release in a real town. Results obtained by the CFD approach were compared with those obtained by a simpler but standard integral model.

Keywords: CFD modeling, atmospheric dispersion, safety analysis, GIS data

Introduction

In production facilities, particularly in chemical production (but also in others such as storage houses, transportation), a leakage of dangerous (toxic or flammable) substances can occur. One of the main questions of risk analysis is the knowledge of the consequences linked with the leakage of dangerous materials. CFD models which allow to fully resolve the wind velocity profile and pollutant distribution became an often used tool in safety analysis and emergency preparedness.

During an industrial accident, a leakage of hazardous substances usually occurs. From the safety engineering point of view, potentially the highest risk is presented by the leakage of pressure liquefied gaseous substances evaporating very quickly. In case of an accident, the material is suddenly depressurized and the resulting jet consists of a gaseous vapor phase and a liquid phase containing particle droplets mixed with air. After evaporation or formation of the gas cloud, dispersion occurs.

Most of the currently used models assume that the distribution of the pollutant concentration in crosswind direction corresponds to the Gaussian distribution (Mannan, 2005). These models are often derived from the analytical solution of the diffusion equation and the corresponding dispersion coefficients are obtained by experimental measurements. Another drawback is the assumption of a constant state of atmosphere, i.e. wind speed and direction, turbulence, air pressure, and temperature. The most remarkable disadvantage of this approach is its limitation to flat terrain (terrain without buildings and other obstructions). These disadvantages are partially eliminated in modern modifications of the Gaussian dispersion

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