Simulation of 3D VCE Blast-Structure Interactions in Near- and Far-Fields

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Abstract

The evaluation of civilian-structure vulnerability to terrorist attacks has become a timely and critical issue after the terrorist attack on the World Trade Center on September 11, 2001. On the other hand, accidental explosions also form a threat to communities in the vicinity of chemical and refinery industries. An important aspect of an explosion is the generation of a blast wave, which is responsible for most of the damage at large distances (far-field) from the explosion source. This paper presents a recently developed object-oriented 3D CFD environment capable of modeling the propagation of blast and shock waves from a vapor cloud explosion (VCE) into the far-field and their interaction with structures or buildings. The integrated environment (Fig. 1) includes: 1) set-up of the computational domain; 2) definition of the initial and boundary conditions; 3) generation of unstructured meshes; and 4) the 3D visualization system. The resolution and fidelity of the simulated blast wave phenomena, performed via a solution of the transient compressible Euler equations, were enhanced by the application of the refinement/coarsening grid adaptive scheme.

The dimension of the explosion source is usually very small within a vast field under consideration, which is referred to the far-field solution. Unfortunately, due to the limitation of the capacity of the current PC, it is impossible to simply run 3D code on PC with desired spatial resolution within both the explosion source and the surrounding environment. To deal with this problem, a special treatment is proposed so that one may use a PC to obtain the 3D far-field parameters such as positive overpressure and impulse at target locations of interest. The influence of the 3D VCE blast wave reflection, focusing and shielding on the blast effect prediction in near- and far-fields will be discussed in detail.

As an example, the influence of buildings within a vapor cloud on the blast prediction is examined thoroughly. The dimension of buildings, the shape and properties of the cloud, and the flame velocity (from subsonic to supersonic) are taken into account.

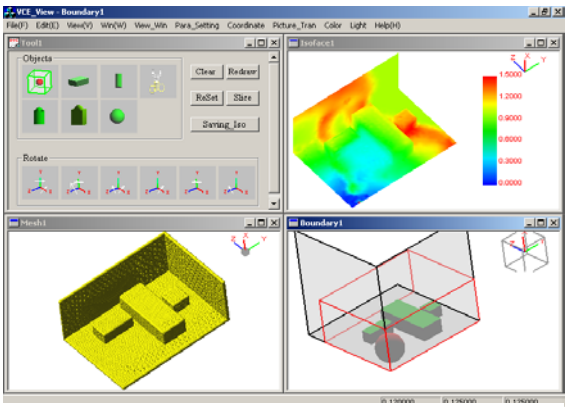

Fig. 1 An object-oriented 3D VCE environment and corresponding visualization system