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Large Eddy Simulation of Hydrogen Deflagration in Open Space and Vented Enclosure

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Abstract : This paper discusses the applicability of the numerical model for a damage prediction method of the accidental hydrogen explosion occurring in a hydrogen facility. The numerical model was based on an unstructured finite volume method (FVM) code “NuFD/FrontFlowRed”. For simulating unsteady turbulent combustion of leaked hydrogen gas, a combination of Large Eddy Simulation (LES) and a combustion model were used. The combustion model was based on a two scalar flamelet approach, where a G-equation model and a conserved scalar model expressed a propagation of premixed flame surface and a diffusion combustion process, respectively. For validation of this numerical model, we have simulated the previous two types of hydrogen explosion tests. One is open-space explosion test, and the source was a prismatic 5.27 m3 volume with 30% of hydrogen-air mixture. A reinforced concrete wall was set 4 m away from the front surface of the source. The source was ignited at the bottom center by a spark. The other is vented enclosure explosion test, and the chamber was 4.6 m × 4.6 m × 3.0 m with a vent opening on one side. Vent area of 5.4 m2 was used. Test was performed with ignition at the center of the wall opposite the vent. Hydrogen-air mixtures with hydrogen concentrations close to 18% vol. were used in the tests. The results from the numerical simulations are compared with the previous experimental data for the accuracy of the numerical model, and we have verified that the simulated overpressures and flame time-of-arrival data were in good agreement with the results of the previous two explosion tests.

Keywords : deflagration, large eddy simulation, turbulent combustion, vented enclosure
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