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DNS MODELLING OF HYDROGEN TURBULENT BUOYANT JET IN A TWO-OPENING AIR-FILLED CAVITY

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We present numerical results from direct numerical simulations (DNS) of an air-hydrogen turbulent buoyant jet in a two-vented cavity, configuration dedicated to analysis of hydrogen distribution in accidental situations for highly confined environments (garage, containment building ...). In the retained configuration, the injection of the light fluid in the floor center leads to the development of a buoyant jet flowing up across a tri-layer concentration structuration, with accumulation of a homogeneous light mixture at the top of the cavity. Most of the studies of literature use helium as injected fluid instead of hydrogen, when experiments are involved for security reason.

This study aims at determining how the nature of the injected fluid modifies the flow structure, and its turbulent mixing properties which are crucial for the species distribution within the cavity. Indeed, despite a similar Schmidt number, the density of hydrogen is more than twice as light as that of helium. Two main numerical difficulties are identified: the large density ratio between the injected and the ambient fluids, the numerical modelling of the two vents where the mass flow rate and the mixture properties are not prescribed [1]. The code TrioCFD in the platform TRUST, developed by CEA [2] is used to carry out parallel computations on several hundred processors. By comparing results obtained with air, helium and hydrogen as injected fluid, we investigate how the turbulent flow properties are altered by the change of the buoyant flux at the injection source, and in particular the buoyancy production term of turbulence. Macroscopic quantities are derived from DNS results and used to confront existing different 1D models describing the light gas distribution inside the cavity, such as [3]. Shortcomings are identified, and a new model accounting for large density differences in an inhomogeneous environment is proposed.

REFERENCES

- [1] E. Saikali, G. Bernard-Michel, A. Sergent, C. Tenaud, and R. Salem. Highly resolved large eddy simulations of a binary mixture flow in a cavity with two vents: Influence of the computational domain. *International Journal of Hydrogen Energy*, 44(17):8856 – 8873, 2019.
- [2] CEA TRUST-TrioCFD code. <http://www-trio-u.cea.fr>
- [3] P.F. Linden, The fluid mechanics of natural ventilation. *Annual Review Fluid Mechanics*, Vol. 31, pp. 201-238, 1999.