IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

PHD THESIS PROPOSAL

Experimental and theoretical study of low frequency combustion instabilities during fire event in confined and mechanically ventilated enclosure

The thesis deals with combustion instabilities during fire events in confined and mechanically ventilated compartments. Because of the limited ventilation capacity of the compartment, fires often feature low levels of oxygen, under-ventilated combustion, and partial or total flame extinction. In addition, in such regimes of combustion, unstable modes are encountered. These instabilities consist in large low frequency variations of the global fire behavior. This situation can be encountered for typical fire scenarios identified in nuclear installations and may have a direct impact on the safety of the installation (loss of the dynamic confinement or mechanical action on the safety devices such as filters or dampers). The objective of the thesis is to study the mechanisms of combustion instabilities during fire events occurring in mechanically ventilated enclosures.

The first part will be dedicated to a theoretical study in order to identify the controlling dimensionless parameters that characterize the appearance of the instabilities and their main properties (frequency and amplitude). The physical mechanisms that contribute to the development of unstable modes will be investigated. These include the processes of fuel formation as a result of pyrolysis inside solid flammable materials, flame extinction, turbulent mixing (mixing of gases of different densities, i.e. hot combustion products and incoming fresh air. The theoretical approach will be supported by experiments at small scale. Advanced diagnostics (LDV, PIV and PLIF) will be applied to characterize the time-space variations of the instabilities. The physical quantities sought are the gas velocity field in the enclosure, the oxygen concentration, the fire power, the flame features (temperature, position, size, movement in the room), the gas temperature and gas pressure. This thesis will be performed with the technical support of Prof. Arnaud Trouvé from the University of Maryland (USA) and Prof. Olivier Vauquelin from IUSTI at Aix-Marseille University.

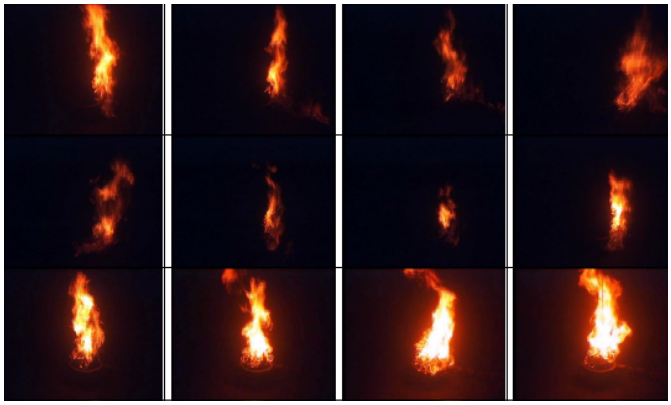
Requirement: Master of Science (or French "Ecole d'Ingénieurs") preferably in Mechanical Engineering, Chemical Engineering or a related discipline (Combustion, Fluid mechanics, Heat transfer).

Location: IRSN - Centre de Cadarache, 13115 St Paul lez Durance, France

Duration: 3 years from sept 2014

Contact Hugues Pretrel, hugues.pretrel@irsn.fr, deadline for application june 2014

Advisors: IRSN (Hugues Pretrel & Sylvain Suard), Aix Marseille University, IUSTI (Olivier Vauquelin), University of Maryland (Arnaud Trouvé)



Sequences of images during combustion instabilities

References:

[1] Kim, K., Ohtani, H. Uehara, Y., Experimental study on oscillating behaviour in a small-scale compartment fire, Fire safety Journal, 20, 377-384, 1993.

[2] Hu Z., Utiskul Y., Quintiere J. G., Trouve A., Towards large eddy simulations of flame extinction and carbon monoxide emission in compartment fires, Symposium International on Combustion, , 2007.

[3] Compartment fire phenomena under limited ventilation, Fire Safety Journal, Y. Utiskul, J. G. Quintiere, A. S. Rangwala, B. A. Ringwelski, K. Wakatsuki, T. Naruse, 2005.