PHD THESIS

SHOCK TO DETONATION TRANSITION IN MEDIA WITH OBSTACLES, WITH HYDROGEN

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The ubiquity of hydrogen as a solution to decarbonize our industries raises major safety concerns related to its deployment: storage, transportation and use. Leakage scenarios from tanks and hydrogen-containing components may even jeopardise the development of hydrogen solution to the energy transition. This is particularly the case in the context of new applications linked to transport [1], and the fact that European aviation regulations do not take account of the specific nature of this fuel [2].

The most classical scenario is the formation of flammable clouds in confined areas, leading to possible *Deflagration-to-Detonation Transition* (DDT).

Indeed, following the presence of a spark, for example, or a shock from an impact, the escalation of events that follows is as follows: a flame will form, then accelerate following the presence of various obstacles, and finally create favorable conditions for the appearance of a detonation. One of the precursors to detonation is the formation of shock waves during the acceleration phase.

Despite continuous efforts for decades, DDT remains an open problem. The thesis will therefore focus on the final stage of DDT, i.e. the SDT Shock-to-Detonation Transition (SDT), which remains a canonical configuration, which has been little explored in the literature.

The experimental set-up used will be based on the TDM50 (50 mm x 50 mm Modular Detonation Tube) (Figure 1) and a thin NaC10 channel. In particular, it will allow visualization on two optical axes. The visualization diagnostics used will be strioscopy (visualization of density gradients and wave dynamics) and chemiluminescence (visualization of combustion fronts). From the matrix of all the parameters, a few specific points will be identified for numerical simulation, in order to clarify the physical mechanisms. This will be based on an in-house code called RESIDENT (REcycling mesh SImulation of DEtonations).

The aim of the thesis is to determine the conditions under which SDT is likely to occur and to characterise this state of detonation. The approach adopted is to combine different methods within an overall approach based on a diptych of experimentation and numerical simulation.

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Références

[1] https://www.aria.developpement-durable.gouv.fr/wp-content/uploads/2020/06/200609_flash_H2_mobilite_vf.pdf
[2] https://www.easa.europa.eu/en/light/topics/hydrogen-and-its-potential-aviation

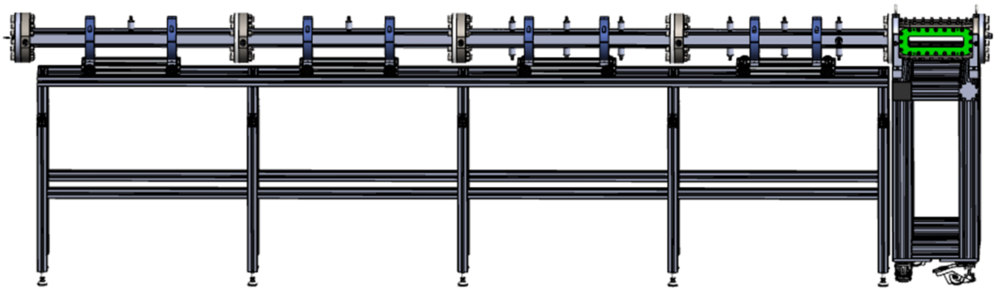

Figure 1 : *Schematics of the experimental apparatus TDM50 - modular detonation tube with a section of 50 mm x 50 mm, with five independent sections.*

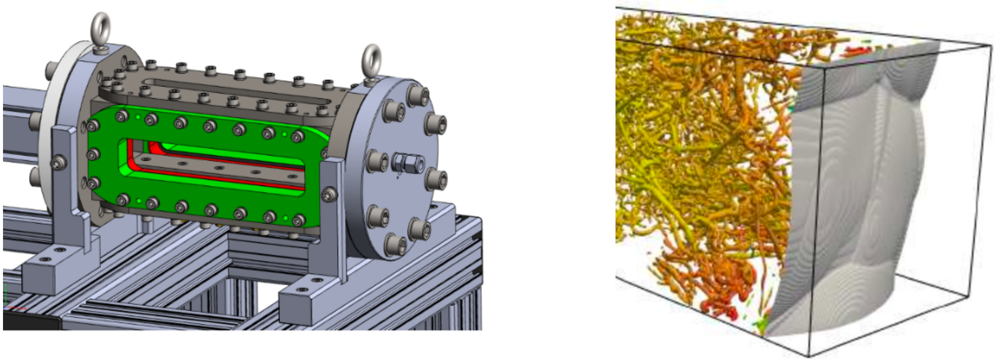

Figure 2 : *left : Vizualisation chamber with two optical axis. Right : Q-criteria for the numerical simulation of a cellular detonation front.*

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