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THE FRENCH AEROSPACE LAB

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DOCTORATE PROPOSAL

Title : Numerical study of injection and mixing in an airbreathing Rotating Detonation Combustor

Reference: **MFE-DMPE-2025-07**

Planned start of the thesis: April 2025	**Application deadline: March 2025**

Keywords : Rotating detonation, combustion chamber, numerical simulation, modelling, injection, mixing

Profile and skills required

Academic training: engineering school and master 2 with a focus on fluid mechanics, propulsion, combustion, detonation, CFD

Personal qualities: autonomy, interpersonal and communication skills, programming skills, ability to use CFD software, fluent English, quality of oral and written scientific expression.

Presentation of the doctoral project, context and objective

The theoretical interest in detonation as a combustion mode, compared to isobaric combustion, lies in an increase in the thermodynamic efficiency of the engine cycle because detonation creates a significant pressure gain in the combustor. The Rotating Detonation Combustor (RDC) potentially offers an innovative solution that can increase propulsion performance or provide system-level improvements with at least equal performance.

On a global scale, there exists a growing interest in research activities related to the use of detonation in different propulsion systems and power plants. Models and prototypes of RDC have been tested on the ground and in flight in different countries (the United States, Japan, Russia, China, France, Germany…). As part of its activities in the RDC research, ONERA has set up several PhD projects in collaboration with the Pprime Institute (CNRS), DLR Institute of Space Propulsion and DSO Singapore. ONERA is actively developing and using its own CFD research code CEDRE to simulate the operation of RDCs and to optimize their elements such as the injector.

This doctoral study is proposed in the framework of the Doctoral Network H2POWRD (Harnessing Hydrogen's POtential With Rotating Detonation), in which it is referenced to as DC04. Its objective is to find an optimum injector design for an RDC fed with gaseous hydrogen and air. An optimized injector must provide efficient mixing, while limiting total pressure losses. The available time to feed and mix the reactants is on the order of 100 µs, depending on the number of waves and their propagation speed. Several injection principles and geometries (shape, size and orientation of the orifices) will be compared according to the mixing efficiency and total pressure recovery criteria. These criteria will be evaluated from LES simulations of the injection and turbulent mixing in an RDC. The best configuration will be studied in more detail and further improved. Injector operation will be characterized in a cold-flow continuous regime, then in a reactive reinjection regime in order to deepen understanding of the injection and mixing processes occurring in an RDC. The optimized injector will be tested on an experimental RDC of TU Berlin in the scope of another doctoral study in H2POWRD (DC01). In parallel, first simulations of the operation of the TU Berlin RDC will be set by selecting appropriate numerical methods and physical models. Post-processing tools will be developed to analyze the mixture formation process in the RDC. The experimental study by DC01 will make it possible to select an operating point of interest to be simulated by DC04 in order to compare the experimental and numerical results. If necessary, the numerical approach will be tuned to achieve agreement with the detonation propagation speed and pressure recordings in the experimental RDC. The final simulation results will provide detailed information about the mixture formation in the RDC and its interaction with propagating detonation waves. Additional mixing simulations will be performed for a radial RDC configuration studied in the scope of DC14.

External collaborations: contacts with the participants of the DN H2POWRD will be established via training sessions and workshops. A secondment (few months) at TU Berlin is planned as part of the doctoral project. More information on the DN and PhD application is available at www.h2powrd.eu.

At the date of recruitment, applicants must fulfill the transnational mobility rule: applicants must not have resided or carried out their main activity (work, studies, etc.) in the country of the recruiting beneficiary for more than 12 months in the 36 months immediately before the recruitment date – unless as part of a compulsory national service or a procedure for obtaining refugee status under the

Geneva Convention.

In parallel with the ONERA application, applicants still must apply through the H2POWRD email (www.h2powrd.eu) as this is our internal records of applications.

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For more information: https://www.onera.fr/rejoindre-onera/la-formation-par-la-recherche