UNIVERSITE D'ORLEANS

## Post-Doc Young Researcher Position:
## experimental study of liquid injection of ammonia in gas turbine conditions

Ammonia is more and more identified as a relevant energy carrier to contribute to the reduction of CO2 emissions of electricity production based on gas turbine. The project ADONIS (selected suite CONCERT-Japan Joint Call on Sustainable Hydrogen Technology as Affordable and Clean Energy) directly seeks answers to three fundamental open questions of high relevance to the development of micro gas turbines (~100 $kW_e$) that use ammonia as energy carrier: 1) flame-wall interaction; 2) combustion dynamics; 3) fuel injection strategy. All these processes have significant impact on the stability, efficiency, emissions and, ultimately, overall cycle performance of the gas turbine.

The injection of ammonia in liquid phase for micro-gas turbine applications could improve the total performance of ammonia gas turbine itself for two main reasons. First, in technological point of view, as ammonia is usually stored in liquid phase, the energy cost would be lower if it is introduced directly in liquid phase rather than in vapor one. Indeed, this way to proceed would avoid the development and the control of vaporizer and dedicated gaseous storage system. Second, the injection of liquid ammonia will induce that the ammonia/air mixture will not be homogeneous but stratified rich to lean. This aspect may allow to simplify the design of the combustor without having to consider two-stage combustors. Nevertheless, using liquid injection of ammonia raise some challenges still to be addressed. Thus, the decrease of the ambient temperature due to its high latent heat of vaporization is not beneficial to guarantee combustion stability, in addition to the low laminar flame speed and the narrow flammability limits range. Moreover, due to the high saturation pressure of ammonia at ambient temperature contrasting to conventional fuels, the flash boiling phenomena may occur, inducing the presence of gaseous phase in liquid jet to favour fast atomisation. This phenomenon is poorly addressed until now in literature and needs to be better characterized to improve the model prediction from CFD tools to help for future designs of injection systems and more globally combustion chambers. In order to reach this aim, the modelling needs to be confronted to the experimental data.

The aim of postdoctoral position concern the realization of an experimental database aiming at characterizing the ammonia spray and subsequent vaporization in different conditions. As suggested in recent paper (Hashim et al., 2017) Gasoline direct Injectors will be selected as a function of their possible compatibility with the use of ammonia (corrosivity of ammonia function of the materials) to provide accurate database on the atomization and vaporization processes of liquid ammonia jet with accurate optical techniques (as schlieren techniques, Back illuminating, Mie scattering and Malvern droplet sizing) for various operating conditions (ambient pressure between 0.1 to 3 MPA with Combustor Inlet Temperature (CIT) between 298K to 500K) representative of conditions commonly achieved in gas turbine combustion systems and different introduction conditions of liquid ammonia (injection pressure and temperature). Experimental data obtained in PRISME will be analyzed jointly with IFPEN in order to provide reference database to adapt or/and develop accurate models for ammonia spray numerical representation.

### *Profile*

Ph.D. in mechanical engineering

Skills:

- Experience of designing and implementing experimental methods, with fundamental knowledge in fluid mechanics and spray injection
- strong experience with optical diagnostics (measurement + image processing tools with Matlab and data analysis)
- oral and written communication to report to the several partners and for congress and scientific journal.

### *Conditions*

Start May 2022

Duration: 12 months

Location: Orléans France, Laboratoire PRISME (https://www.univ-orleans.fr/fr/prisme)

Gross salary between 2500€ and 3500€ depending on the applicant's experience

PRISME

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Reference

- Pelé et al., First study on ammonia spray characteristics with a current GDI engine injector, FUELS 2021,
- www.mdpi.com/journal/fuels
- Hashim et al., Effects of Fuel and Nozzle Characteristics on Micro Gas Turbine System: A Review, Materials Science and Engineering 226 (2017) 012006 doi:10.1088/1757-899X/226/1/012006
- Okafor et al., Flame stability and emissions characteristics of liquid ammonia spray co-fired with methane in a single stage sw Fuel 287 (2021) 119433
- J. Dernotte, C. Hespel, F.Foucher, S.Houillé, C. Mounaïm-Rousselle, Influence of fuel properties on the Diesel Injection process in non vaporizing conditions, atomization and spray, volume 22 (6) , 2012, pages 461-492