Phd thesis tittle: Improving the Ignition of Ammonia Engines

PRISME laboratory (https://www.univ-orleans.fr/en/prisme/projects/ongoing-projects/ammonia-fuel)

Storing renewable electricity in high energy density vectors is crucial, not only for the energy sector, but also for sectors that are difficult to electrify, such as maritime transport, heavy goods vehicles, rail, aviation and heavy industry. While hydrogen is often seen as a promising solution, its low energy density by volume makes it expensive to transport. Ammonia, on the other hand, appears to be an ideal hydrogen carrier thanks to its high energy density, relatively low cost and ease of liquefaction, storage and transport. It is therefore possible to use ammonia directly as a carbon-free fuel.

However, an energy system based on the combustion of ammonia faces several scientific and technological challenges. Pure ammonia has the combustion properties required for today's internal combustion engines, due to its low reactivity and low flame speed. An ignition promoter, such as hydrogen or a biofuel, is often required to ensure stable and efficient combustion. In addition, ammonia emits pollutants such as nitrogen oxides (NOx), nitrous oxide (N_2O) and unburned ammonia. To date, it is not straightforward to use ammonia in engines while guaranteeing high efficiency and low emissions.

The aim of this thesis is to explore ignition processes adapted to internal combustion engines running on ammonia. Two ignition systems will be studied:

1. Pilot injection of reactive fuel: The addition of reactive fuels (such as decane or n-heptane) facilitates ignition and stabilisation of combustion. Optical techniques will be used to analyse the mixture fraction and ignition mechanisms in a single-stroke engine.

2. Active pre-combustion chamber: This system promotes improved combustion via the local generation of hydrogen (by cracking ammonia) or the production of reactive mixtures in a pre-combustion chamber. New optical diagnostics (such as LIF for hydrogen) will be developed to characterise these phenomena.

These approaches will be tested in a single-cylinder engine to assess their performance in terms of efficiency and reduction of pollutant emissions. The last objective is to contribute to the development of engines capable of using ammonia as their main fuel, thereby promoting the energy transition in sectors that are difficult to decarbonise.

The thesis will follow this schedule

First year : Bibliography, development of optical techniques (LIF) and post-processing, familiarisation with experimental equipment

2nd year: Experiments in non-engine optical chambers, analysis of results, writing of papers

3rd year : Experiments on optical access and metal single cylinder engine, analysis and rewriting of papers and thesis

Key-words :	**ammonia, ignition, engine, optical diagnostics**
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Beginning	10/2025
Financial support	University , region centre or ADEME Salary function of the financial support (minimum 1700 euros/month)
skills	Master or engineering school in fluid mechanics, thermal science, mechanical engineering Matlab tool

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