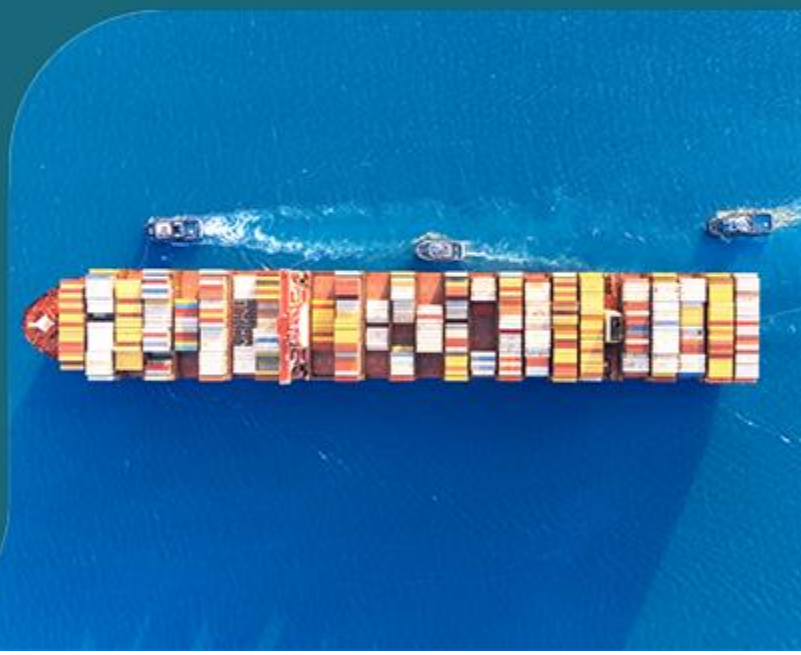
Ignition-promoted Ammonia-Hydrogen for Marine Powertrain



The Challenge

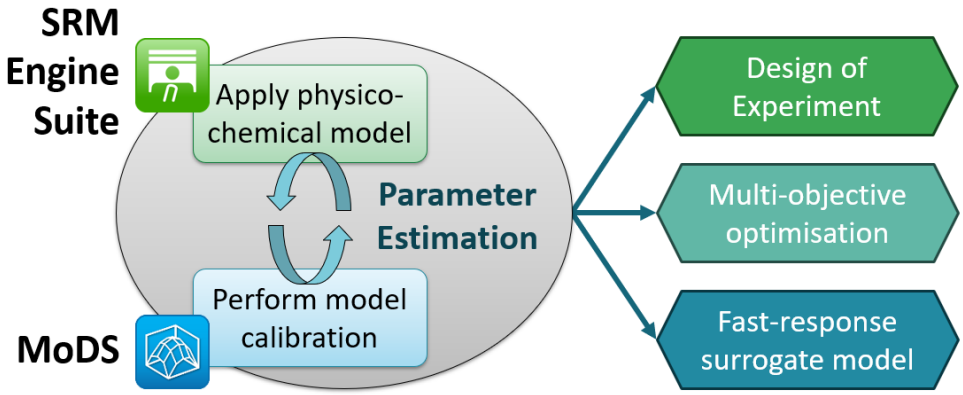
Zero-carbon fuels like ammonia (NH_3) and hydrogen (H_2) are being increasingly adopted in the maritime industry to reduce greenhouse gas emissions. But the use of such fuels in compression ignition (CI) engines is challenging due to high auto-ignition temperatures and low flame speeds.

Our Solution

CMCL's SRM Engine Suite enables researchers to investigate the use of aqueous hydrogen peroxide (H_2O_2) as an ignition promoter in a homogeneous NH_3/H_2 fuelled CI engine, exploring various blend ratios, injection strategies, and engine parameters to optimise performance and emissions.

Key Results

Aqueous H_2O_2 successfully ignited NH_3/H_2 charges, achieving engine loads of up to 93% of the rated power by adjusting the equivalence ratio, with optimal injection strategies and Exhaust Gas Recirculation (EGR) reducing pressure rise rates and NO_x emissions.



"The advanced physico-chemical modelling and data analytics capabilities of CMCL's software enables us to efficiently calibrate and validate across multiple engine operating conditions for carbon-free fuelled marine applications."

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OVERVIEW

The results of study "Engine performance and emissions from a fumigated hydrogen/ammonia compression ignition engine with a hydrogen peroxide pilot" by Gregor Paterson, Efstathios-Al. Tingas, Yannis Hardalupas, and Alexander M.K.P. Taylo, are published in *International Journal of Hydrogen Energy*, 67, 334-350 (2024). CMCL's SRM Engine Suite was deployed to explore the potential of using aqueous hydrogen peroxide (H_2O_2) as an ignition promoter in ammonia (NH_3)/hydrogen (H_2) fuelled compression ignition (CI) engines for marine applications. The study investigated various parameters, such as fuel blend ratios, injection strategies, Exhaust Gas Recirculation (EGR), and engine load, to optimise performance and emissions. The results demonstrate that aqueous H_2O_2 could successfully ignite NH_3/H_2 charges, achieving high engine loads while reducing pressure rise rates and NO_x emissions with optimal injection strategies and EGR. This research contributes to the development of cleaner and more sustainable propulsion systems for the maritime industry, helping to meet the International Maritime Organisation (IMO)'s goals for reducing greenhouse gas emissions from ships.

The study demonstrated that the engine could operate at a wide range of loads, from 44% to 93% of its rated power, while using a small amount of aqueous H_2O_2 as an ignition promoter. The volume of H_2O_2 required was found to be as low as 2.7% of the volume of the primary fuel, NH_3, while still maintaining acceptable pressure rise rates and low emissions. This finding highlights the effectiveness of using aqueous hydrogen peroxide as an ignition promoter in ammonia/hydrogen-fuelled compression ignition engines.

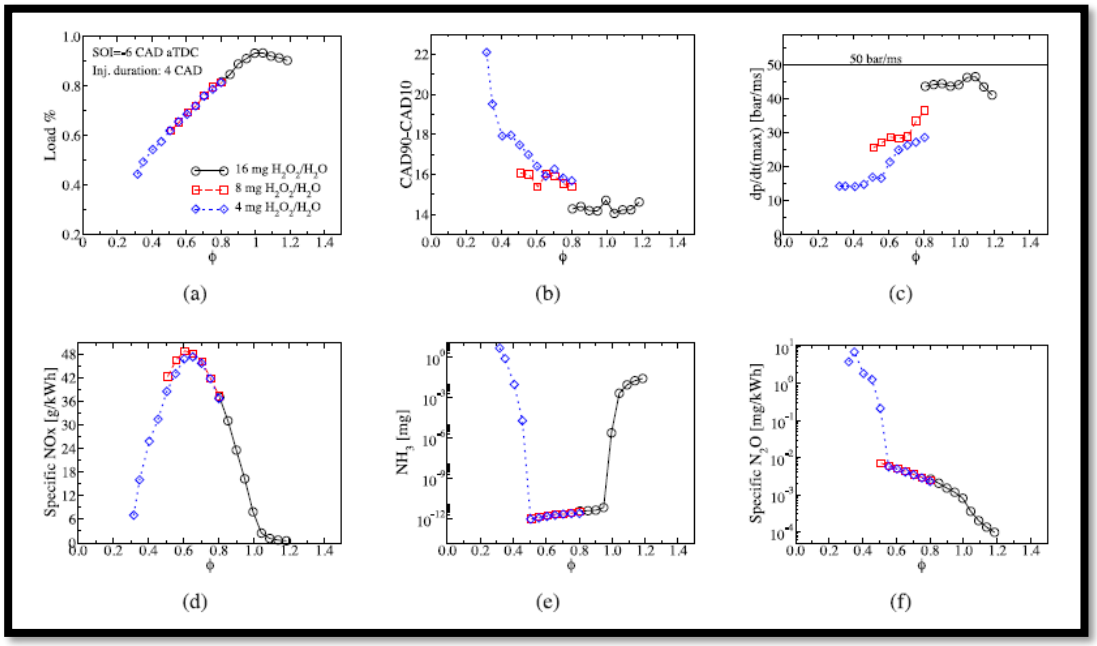

Figure 11 from Paterson et al. (2024)'s paper depicts the change in load, combustion duration, pressure rise rate, and emissions as a function of the initial equivalence ratio for different cases of directly injected masses.

What we can offer:

- Combined physico-chemical and data-driven simulation approach to develop alternative-fuelled IC engines
- Support for full model development cycle, including **parameter estimation** and **multi-objective optimisation**.
- Generation of **fast-response surrogate** models to integrate with full-scale system simulations.

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