Prechamber ignition also

Results and Discussions

Various ammonia combustion concepts are employed at the test rig and evaluated in this study. Firstly, pilot fuel ignition is compared to reactive jet ignition using an optically accessible pre-chamber, see Figure 2. Secondly, ammonia and hydrogen as pre-chamber fuels are compared against each other to deliver a fundamental understanding of pre-chamber-ignited ammonia combustion.

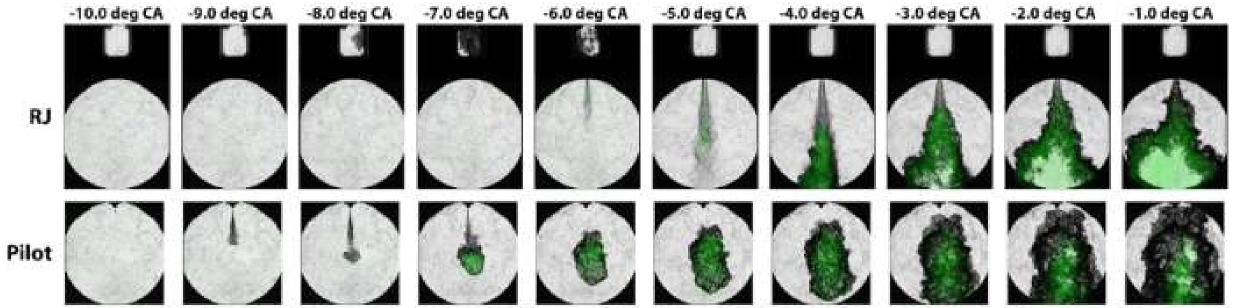

Figure 2. Superposition of simultaneously applied Schlieren and OH*-chemiluminescence measurements of reactive jet (optical pre-chamber) vs. pilot fuel ignited ammonia combustion at operation parameters $\lambda = 1.25$, p_c =70 bar, $T_{in} = 150$ °C, SOI / SDC = −10° CA.

Conclusions

The results of the present investigations are expected to serve as an excellent basis for the selection of a ignition source and pre-chamber fuel, and further optimization of ammonia combustion systems for large marine engines as well as further engine types using ammonia as main fuel and pre-chambers as ignition sources. The optical data in combination with the thermodynamic data delivers a broad insight into ammonia combustion behaviours and the well-characterized test bench can be used to produce validation data for CRFD-Simulations. Under engine conditions, ammonia delivers higher flame speeds than expected from its laminar burning velocity. From a combustion perspective, ammonia thus serves as carbon-free fuel, at least for the maritime sector.

The Journal of Ammonia Energy

Cardiff University Press | Gwasg Prifysgol Caerdydd

2nd Symposium on Ammonia Energy

Optical Investigation of Ammonia Combustion Concepts: Pilot Fuel vs. NH_3- or H_2-Filled Pre-chamber

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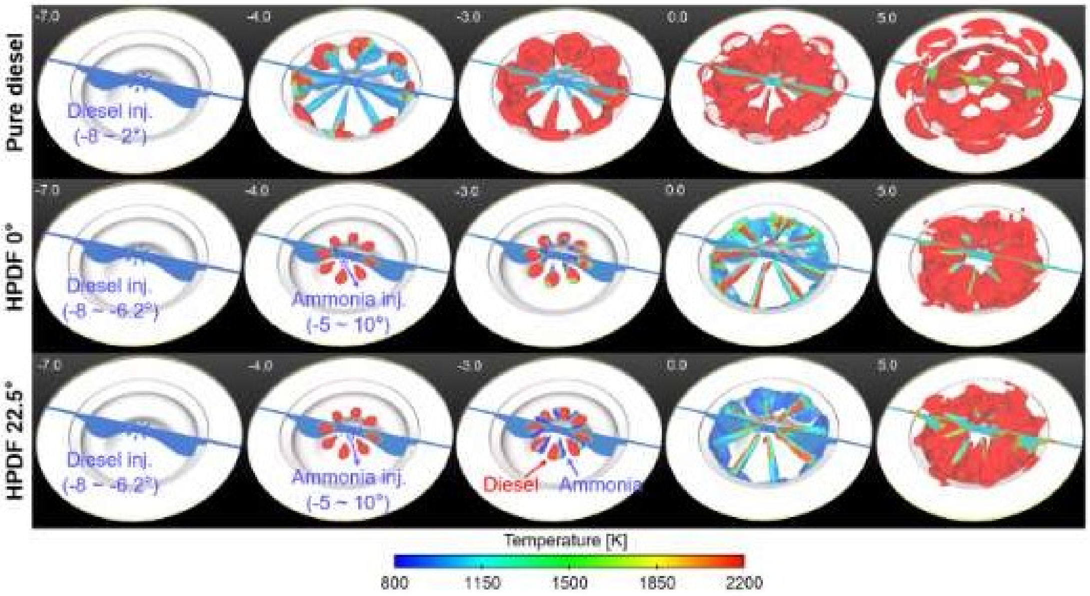
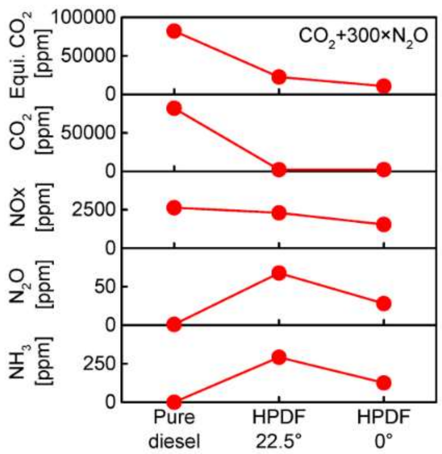
Can we simulate ammonia engine with high accuracy and predict ammonia combustion especially without experimental validations?

1

2

3



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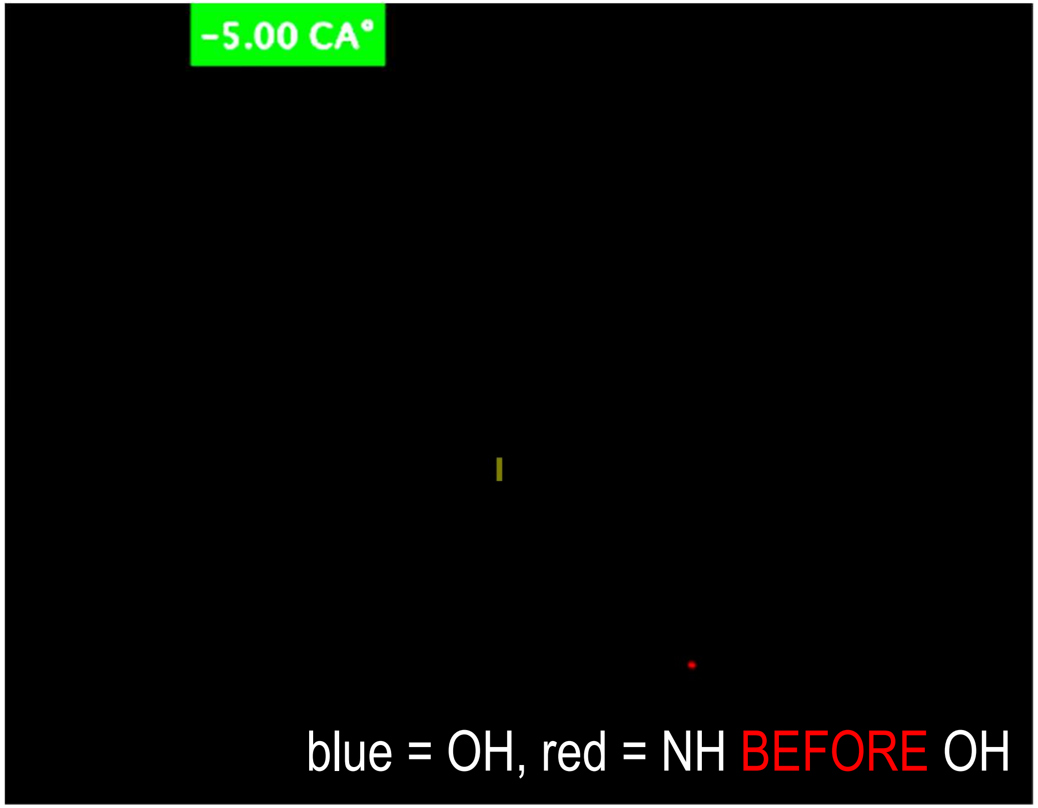
Pilot diesel-ignited ammonia dual fuel low-speed marine engines: A comparative analysis of ammonia premixed and high-pressure spray combustion modes with CFD simulation

Xinyi Zhou [a,b], Tie Li [a,b,*], Ning Wang [b], Xinran Wang [b], Run Chen [a,b], Shiyan Li [a,b]

Ammonia flame propagation In ICE

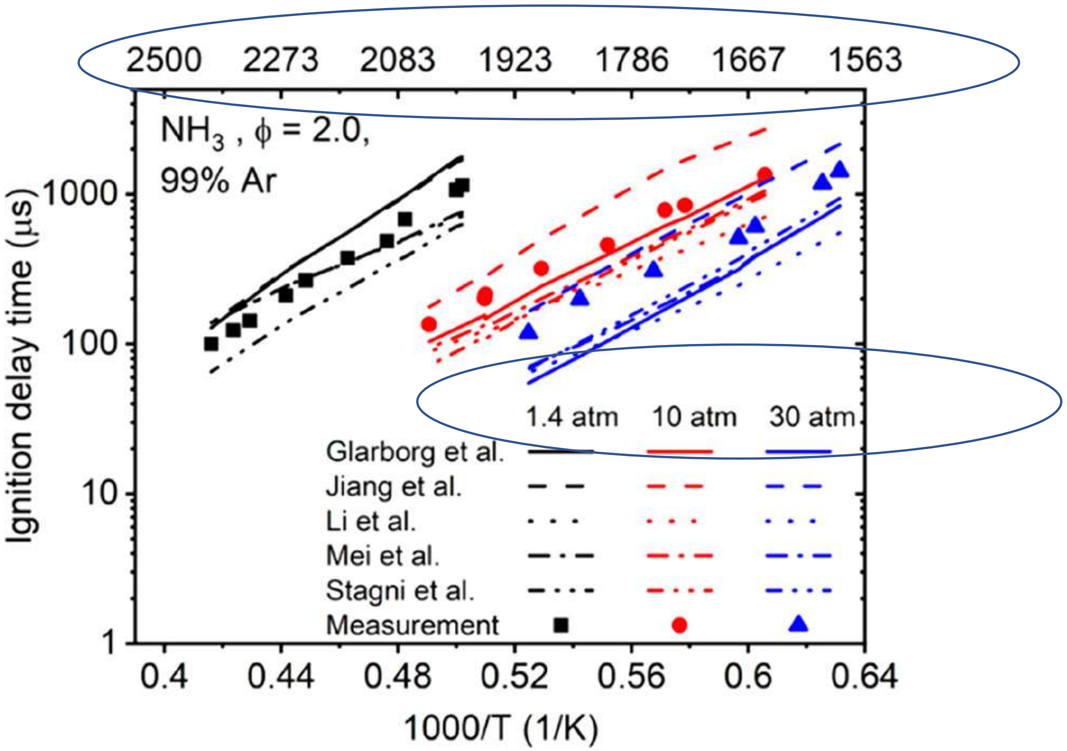
- Decane with ammonia (SOI 22 CAD bTDC)



- Minimum decane quantity : no OH from decane flame
- Decrease of decane quantity : NO OH, NO IGNITION

- Ammonia replaced by N_2
- Ignition of the Diesel Pilot !

Auto-Ignition delay



Comparison between simulation results with the selected mechanisms and the measureme
from Mathieu and Petersen(70) for ignition delay times of fuel-rich NH3/O2/Ar mixtures with
at shock tube conditions. Lines, simulation; symbols, measurement.

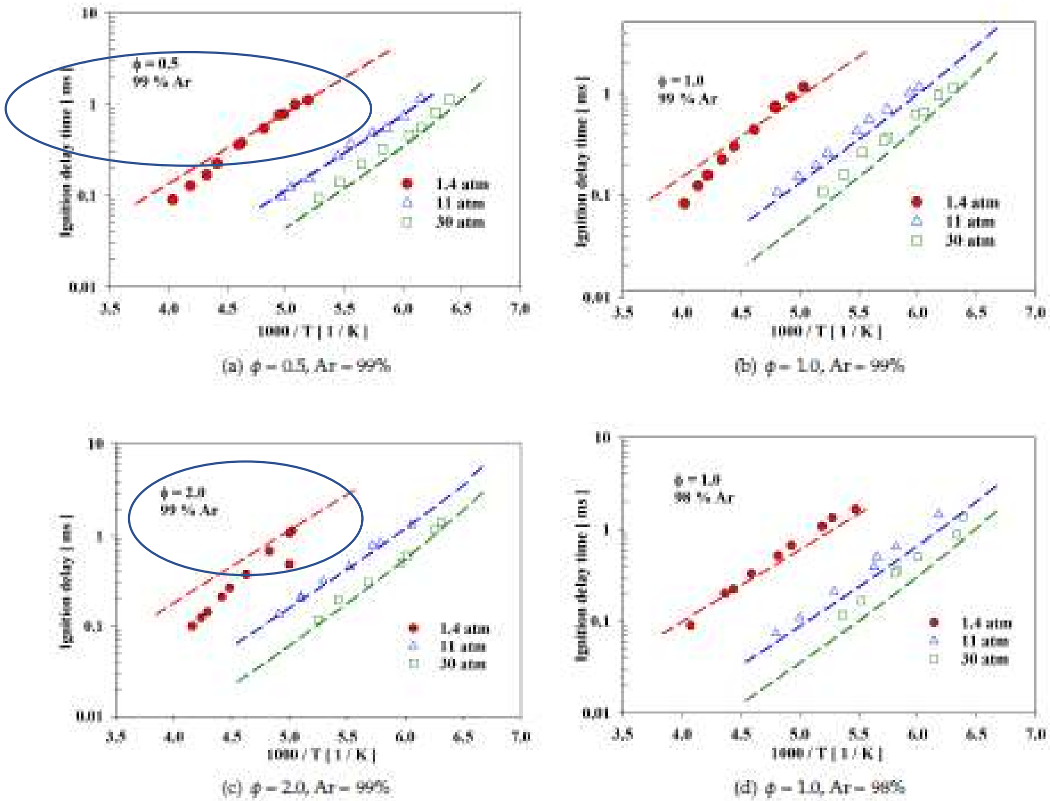


Figure 70: Ignition delay time of $NH_3/O_2/Ar$ at ϕ = 0.5, 1.0 and 2.0 and at pressure of 1.4, 11 and 30 at
Symbols: experimental data from [59], lines: this work.

Shretha et al., PROCI 2021, PHD thesis BTU 2021

Auto-ignition delay

❑Impact of ammonia on n-heptane ID

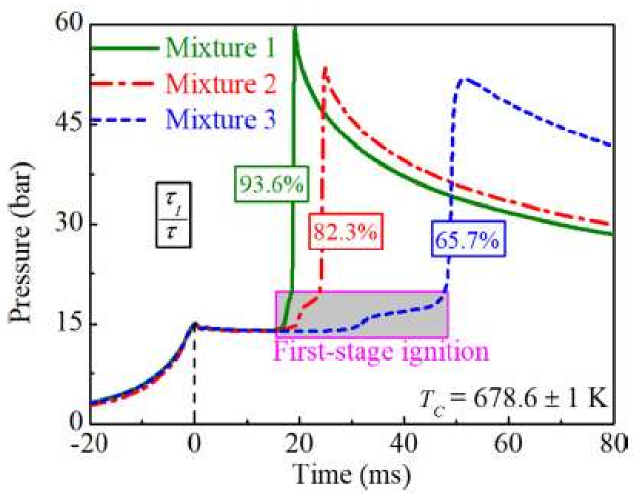


Fig. 4. Comparison of the experimental autoignition pressure curves of n-heptane/NH_3 blending fuels with NH_3 fractions of 0% (mixture 1), 20% (mixture 2), and 40% (mixture 3).

NH_3 + OH < = > NH_2 + H_2O

- the largest negative sensitivity at 20% and 40% NH_3 blends (as expected).
- Consumption of lot of radicals, lower rate of the low- T reaction of n-heptane, thus greatly delaying the first-stage ignition

NH_2 + HO_2 < = > H_2NO + OH

- Unique positive sensitivity reaction of the NH_3 subset
- Consumption HO_2 radical, production of active OH radical
- Promoting the autoignition of NH_3 /n-heptane blend.

First kinetics mechanism

Combustion and Flame 217 (2020) 4–11
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Combustion and Flame
journal homepage: www.elsevier.com/locate/combustflame

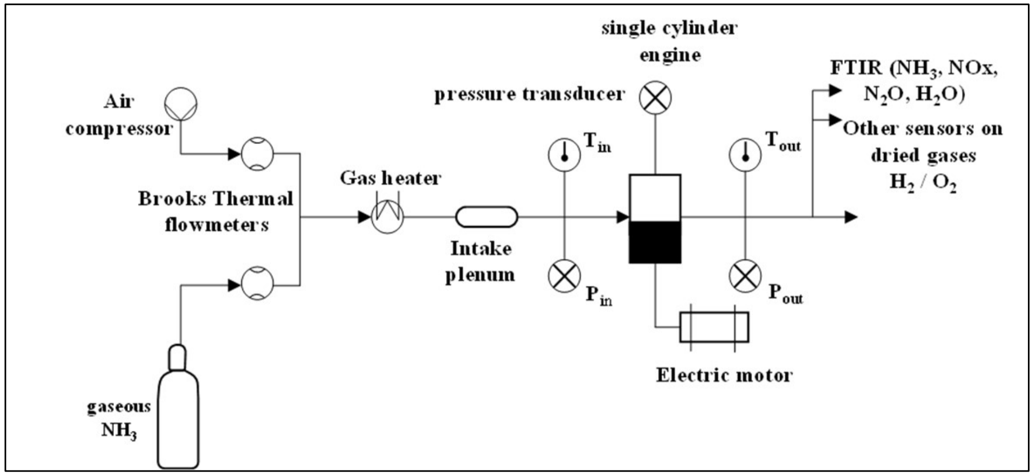
The effect of ammonia addition on the low-temperature autoignition of n-heptane: An experimental and modeling study

Liang Yu, Wei Zhou, Yuan Feng, Wenyu Wang, Jizhen Zhu, Yong Qian, Xingcai Lu*
School of Mechanical Engineering, Shanghai Jiao Tong University, 800 Dongchuan Road, Shanghai 200240, PR China

Comparison between Spark Ignition and Pilot Reactive fuel ignition

- Same engine with premixed gaseous NH_3/air intake
  - no injector
- 2 configurations :
  - Original CRI Bosch injector
    - Minimum diesel content/ optimum engine stability
    - Injection Pressure 200 bar, duration : 350-1000 µs
  - Spark plug
    - Ignition timing set for same CA50

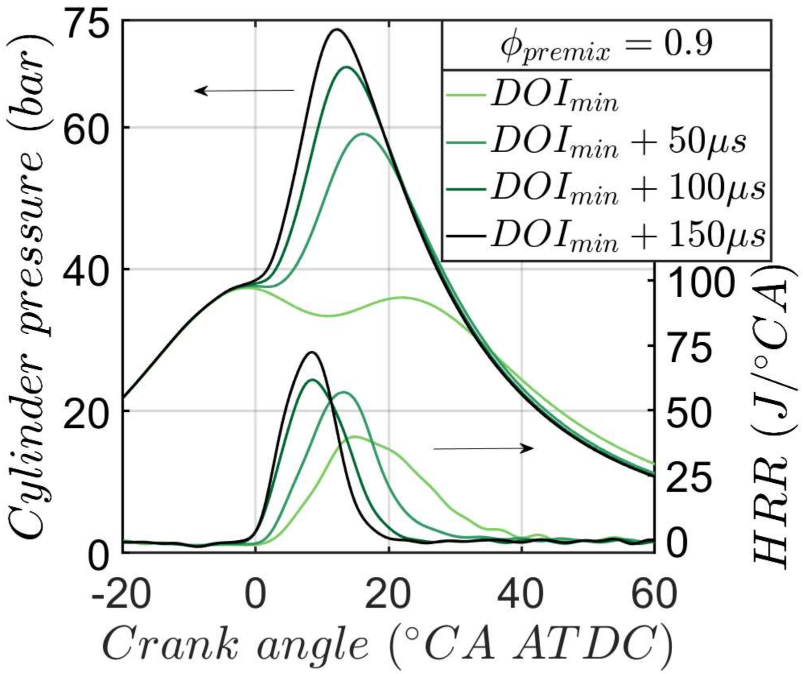
Engine	DW10
Displaced Volume [cm^3]	499.4
Stroke [mm]	88
Bore [mm]	85
Compression ratio [-]	16.4:1
Number of valves [-]	4
Swirl ratio (50 CAD BTDC)	2.0
Bowl type (baseline)	Re-entrant

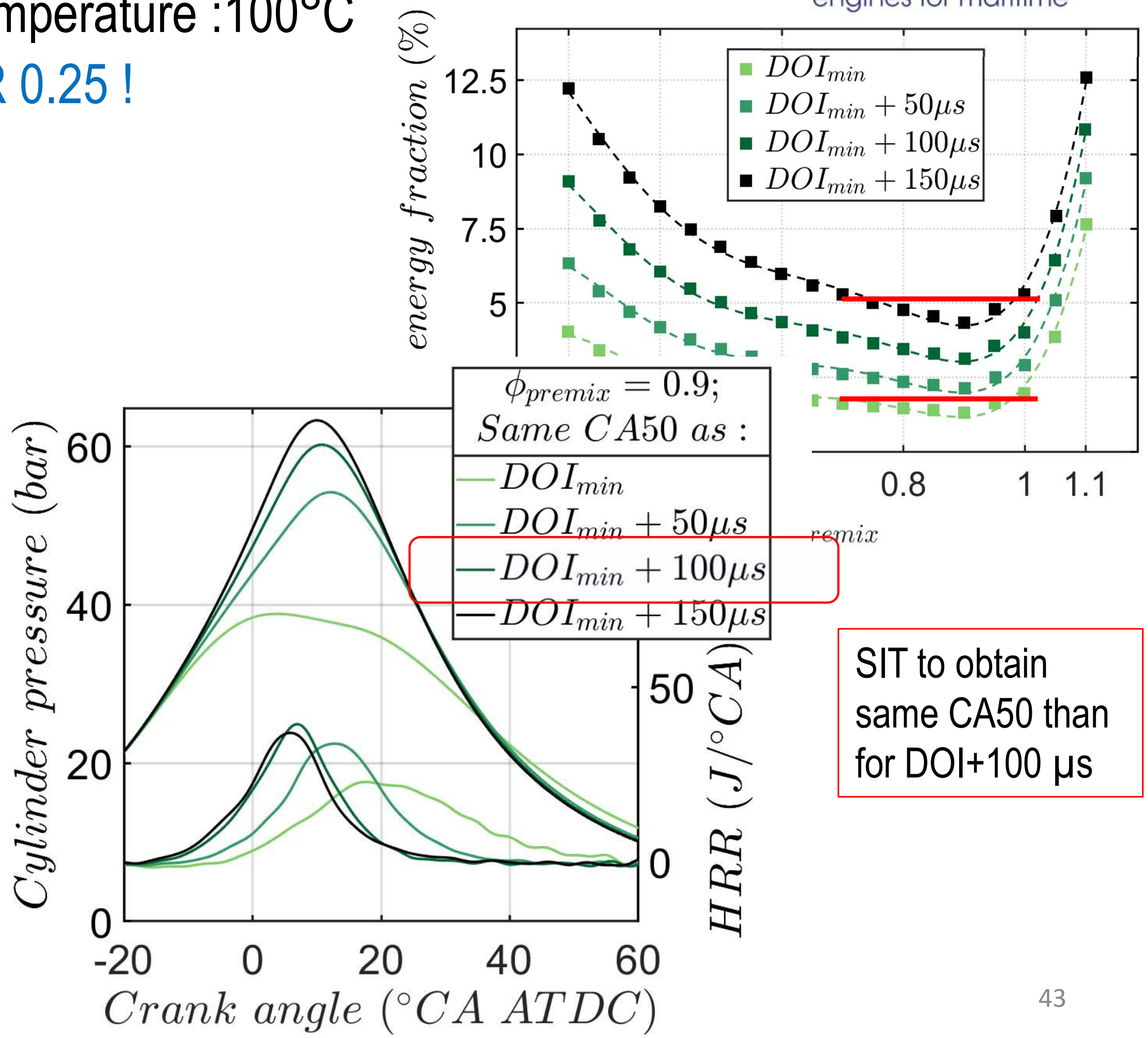


Comparison between Spark Ignition and Pilot Reactive fuel ignition

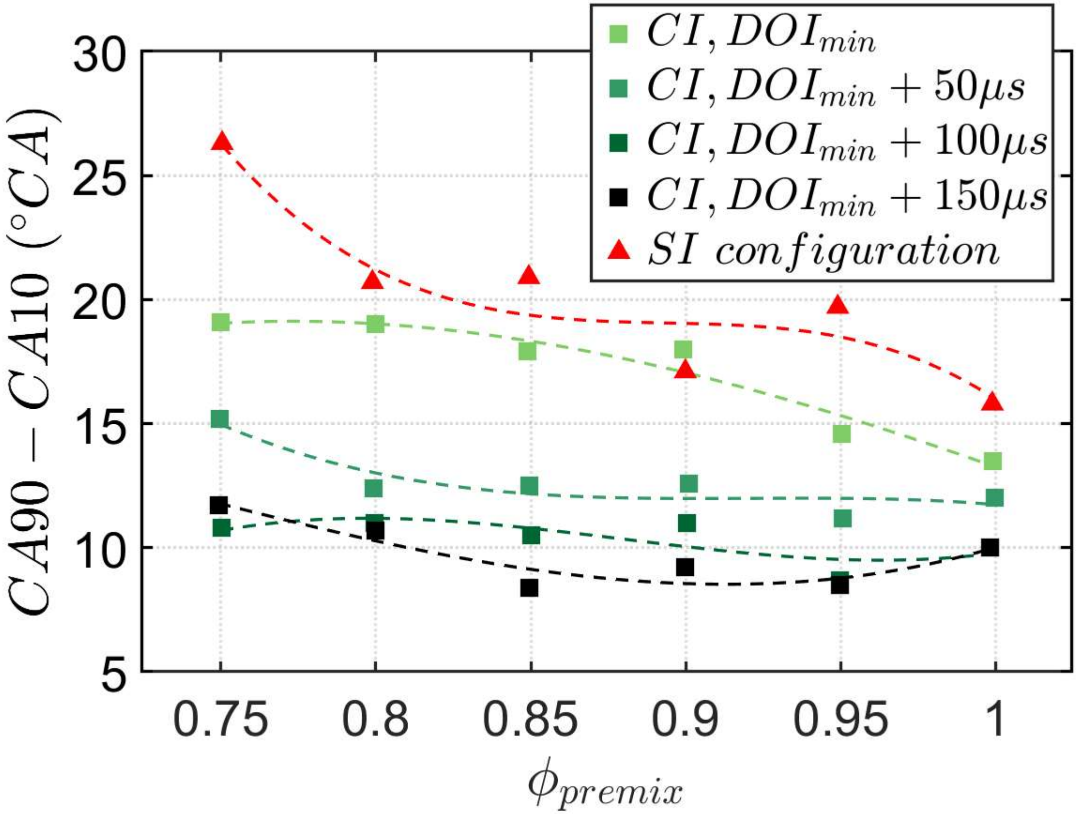
MariNH$_3$ Clean, green ammonia engines for maritime

- N=1000 rpm, intake pressure: 1 bar, intake temperature :100°C
  - RCCI : possible until premixed NH_3/air ER 0.25 !
  - SI : not possible ER < 0.75 :
  - **Common ER range 0.75 to 1**
    - **Diesel** energy **content** : **0.8 to 5%**

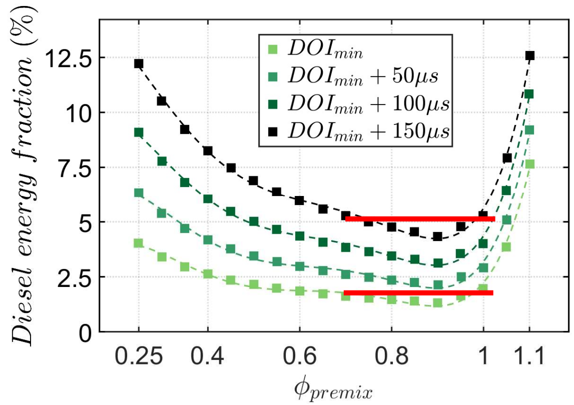




Comparison between Spark Ignition and Pilot Reactive fuel ignition



- Higher load for RCCI due to diesel fraction
- Longer combustion duration for SI
  - strong enhancement by diesel combustion
  - By turbulent spray ? (low Pinj…)

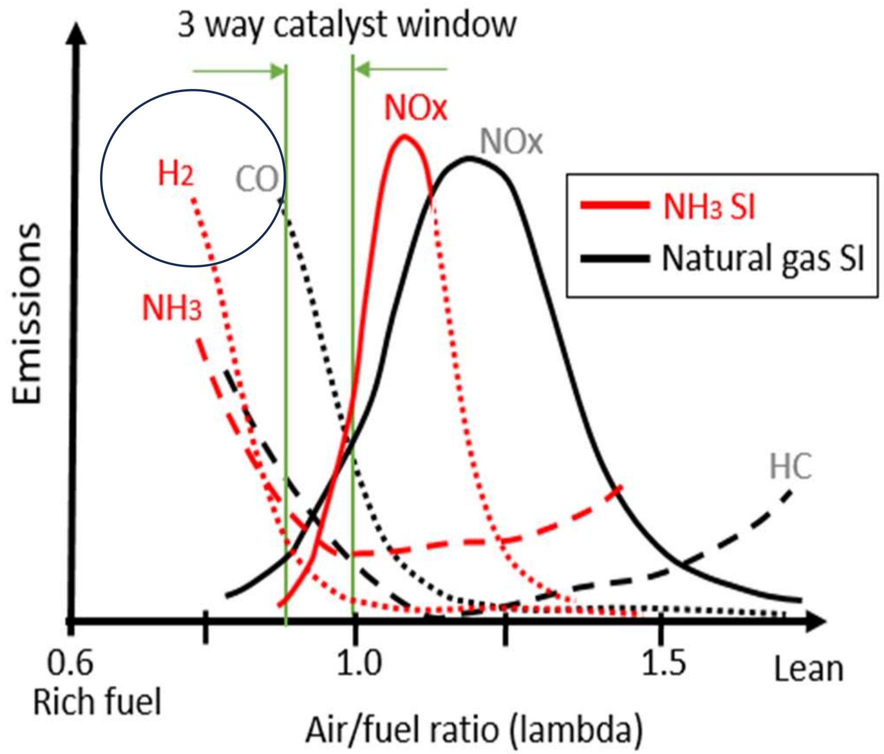


Last important question :

What emissions for what engine fuelled with ammonia ?

Premixed ammonia SI engine

- Similar trends as usual SI engine



- **NO_X**
  - Minimum for **rich mixture**,
    Maximum around 0.7-0.8 until 5000 ppm !
  - Increase with H_2 addition
- **NH_3**
  - Minimum for lean mixture/stoichiometry, max can be 4%
  - Function of engine design ! Crevice trap !
  - H_2 emissions due to 'in situ' cracking of NH_3