Can Ammonia be a Safe and Clean Fuel for Engines?

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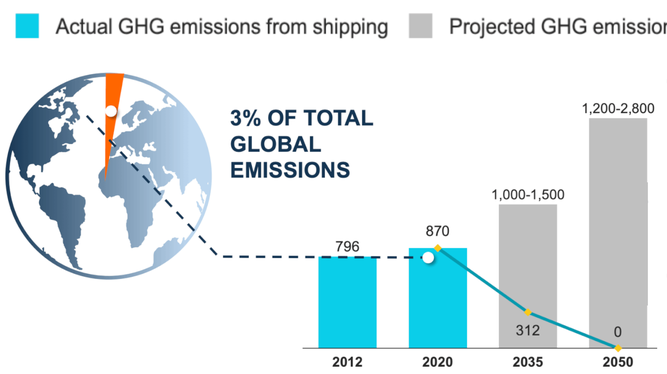
Decarbonising transport



- Shipping contributed 2.97% of total global anthropogenic greenhouse gas emissions (2022).
- IMO's strategy on 'zero carbon emission' in shipping industry by 2050.

Adapted from https://windward.ai/blog/building-the-silicon-valley-of-zero-carbon-shipping/

Diesel engines are difficult to replace, especially on heavy duty powertrains

Literal zero carbon fuels help reduce GHG emissions: H_2, NH_3

Diesel engine consumable liquid zero carbon fuel is necessary ∴ aqueous ammonia

Anhydrous ammonia

Volatile, problematic for storage

Aqueous ammonia [NH_4OH]

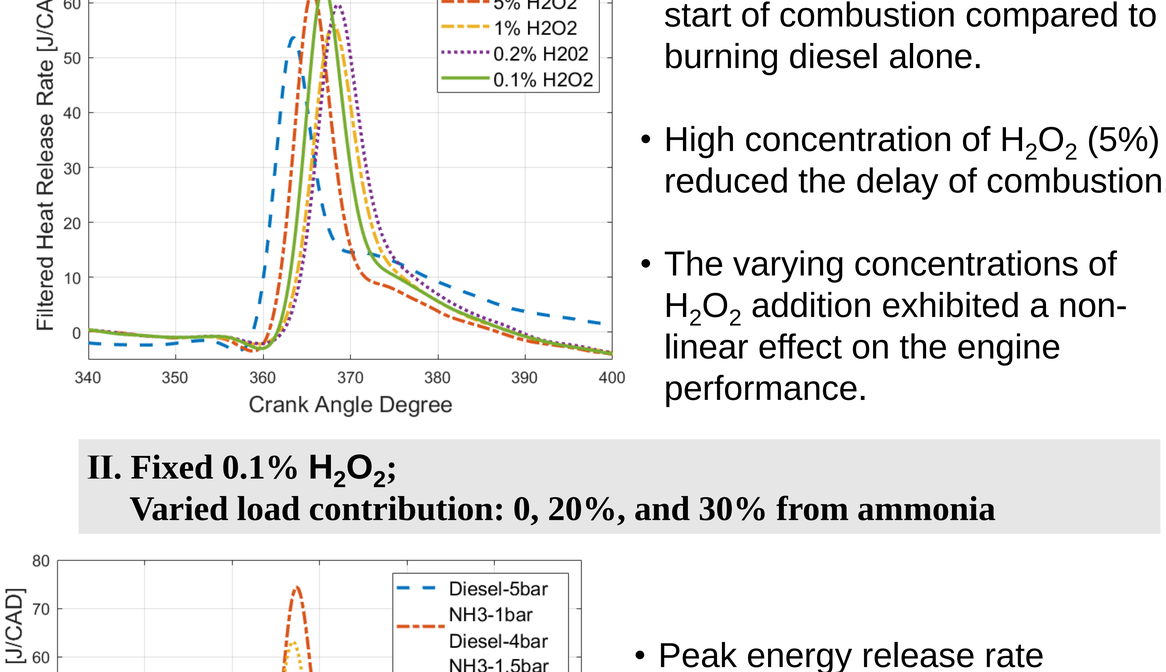
Can be stored safely in sealed container [28% solution used]

Ammonia with additive

H_2O_2 ; NH_4NO_3

Improve combustion

Experiment setup

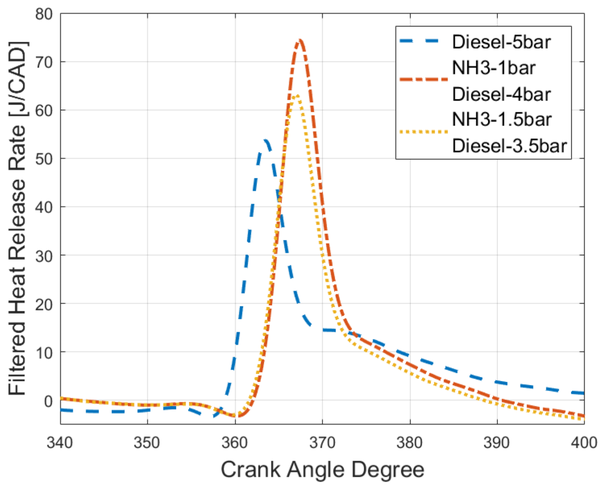


Results and discussions

I. Fixed load contribution: 30% from ammonia; 70% from diesel
Varied the concentration of H_2O_2 added in combustion

- Aqueous ammonia saw a later start of combustion compared to burning diesel alone.
- High concentration of H_2O_2 (5%) reduced the delay of combustion.
- The varying concentrations of H_2O_2 addition exhibited a non-linear effect on the engine performance.

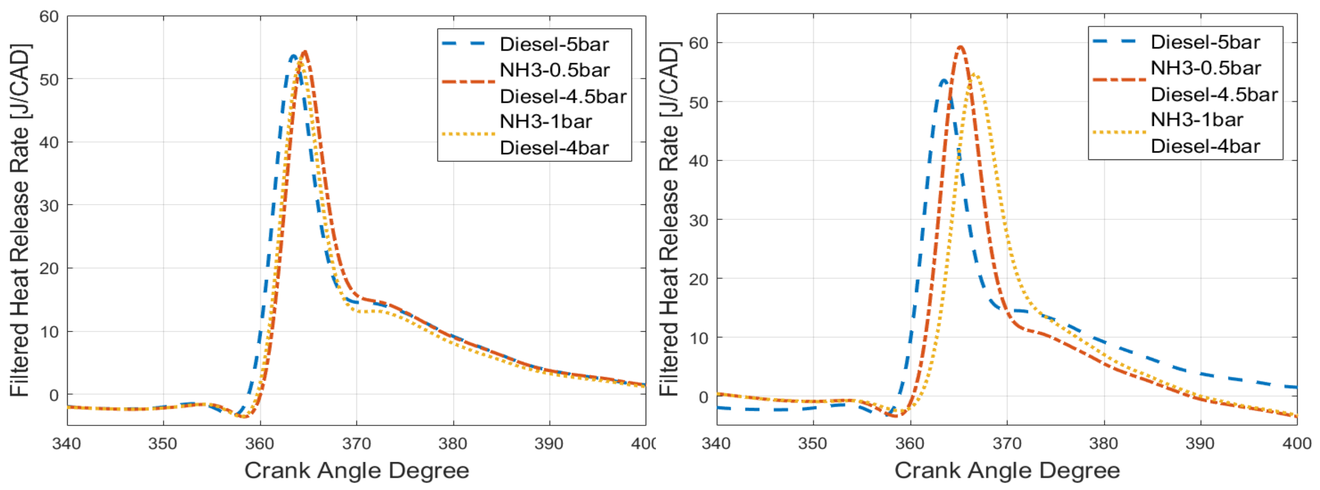
II. Fixed 0.1% H_2O_2;
Varied load contribution: 0, 20%, and 30% from ammonia



- Peak energy release rate increased as ammonia combustion contributed to engine load.
- Aqueous ammonia could supply up to 30% of the engine load before combustion became unstable.

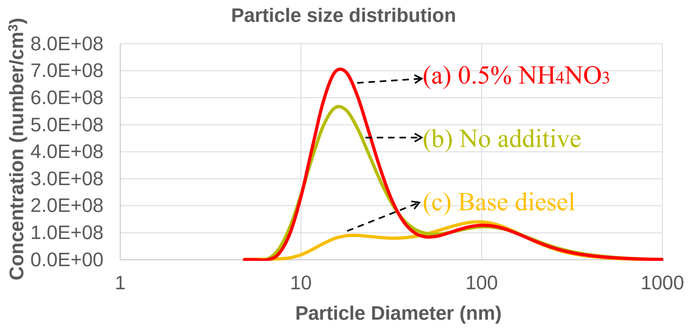
III. Dual-fuel combustion with and without NH_4NO_3 additive

(a) 0.5% NH_4NO_3 additive (b) No additive

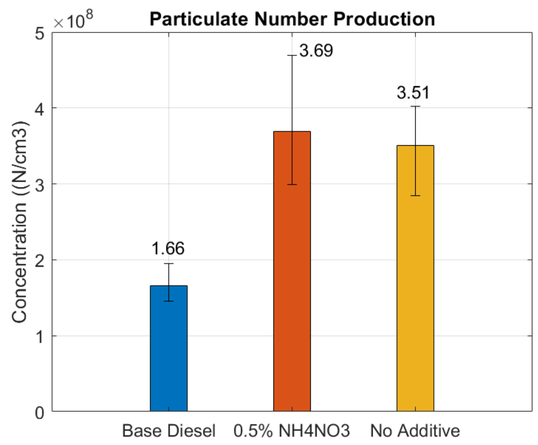


- NH_4NO_3 does not significantly change the peak heat release rate
- 0.5 % NH_4NO_3 offsets the increases in delay of combustion observed with an increasing contribution of aqueous ammonia to engine load

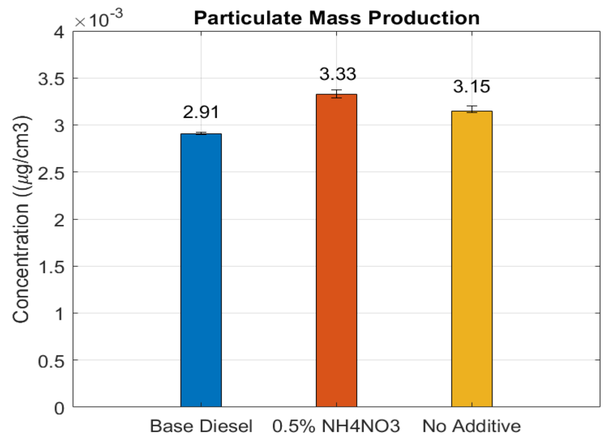
IV. Results of DMS Particulate Analyser of the exhaust
Fixed load contribution: 20% from ammonia; 80% from diesel



- Aqueous ammonia increased ultrafine particles (10-50 nm), which could be a great concern of human health.

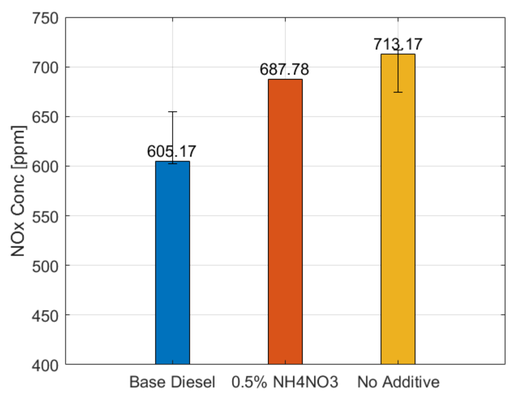


- Total particle number increased with burning ammonia (ultrafine mode).
- Additive presented further increased the particle level, despite its positive effect on combustion performance



- Ammonia combustion increases particle mass.
- Additive presented further increases particle mass.
- Particle compositional analysis will be essential to understand the toxicology.

V. Results of NO_X formation from Fixed load contribution: 20% from ammonia; 80% from diesel



- Ammonia did not increase NO_X formation linearly with fuel-bound Nitrogen.
- The presence of 0.5% NH_4NO_3 reduced the NO_X levels compared to combustion without additive.

Summary

Aqueous ammonia contributes energy release in with diesel co-combustion.

Burning ammonia can be more effective with ignition additives.

Aqueous ammonia has significant impact on particulate size, mass, but limited impact on NO_X.

For any query, please contact

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