

# Experimental H<sub>2</sub>-ICE study using a heavy-duty single-cylinder setup

- Increasing the load range at low engine-out NO<sub>x</sub> emissions -

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The port fuel injected spark ignited hydrogen combustion engine is considered as an attractive technology for realizing the global CO<sub>2</sub> reduction targets. Next to zero CO<sub>2</sub> emissions, the lean burn operation also has the potential for low engine-out NO<sub>x</sub> emissions. However, the use of port fuel injection is known to limit maximum power density caused by the engine charging hardware constraints. In this paper, the NO<sub>x</sub> reduction potential of the port fuel lean burn spark ignition hydrogen engine concept is investigated. Furthermore, the feasibility of extending the load range for low NO<sub>x</sub> operation by use of changes to the engine's compression ratio and application of exhaust gas recirculation is examined. For this purpose a 1.8L heavy duty single-cylinder research platform is used.

The lean burn spark ignited hydrogen combustion engine concept has the potential for realizing ultra-low engine-out NO<sub>x</sub> emissions over a wide load range, see also Fig. 1. Engine-out NO<sub>x</sub> emissions below 0.02 g/kWh have been observed and NO<sub>x</sub> emissions remained below 0.2 g/kWh up to 17 bar BMEP. At this load, further NO<sub>x</sub> reduction is limited by the maximum achievable boost pressure. The load range for low NO<sub>x</sub> was extended by optimizing the compression ratio and application of exhaust gas recirculation, see Fig. 2. This allowed a reduction of the air-excess ratio to 2.1 resulting in a maximum engine load of ~21 bar. At this maximum load point engine out NO<sub>x</sub> was still low at 1.6 g/kWh.

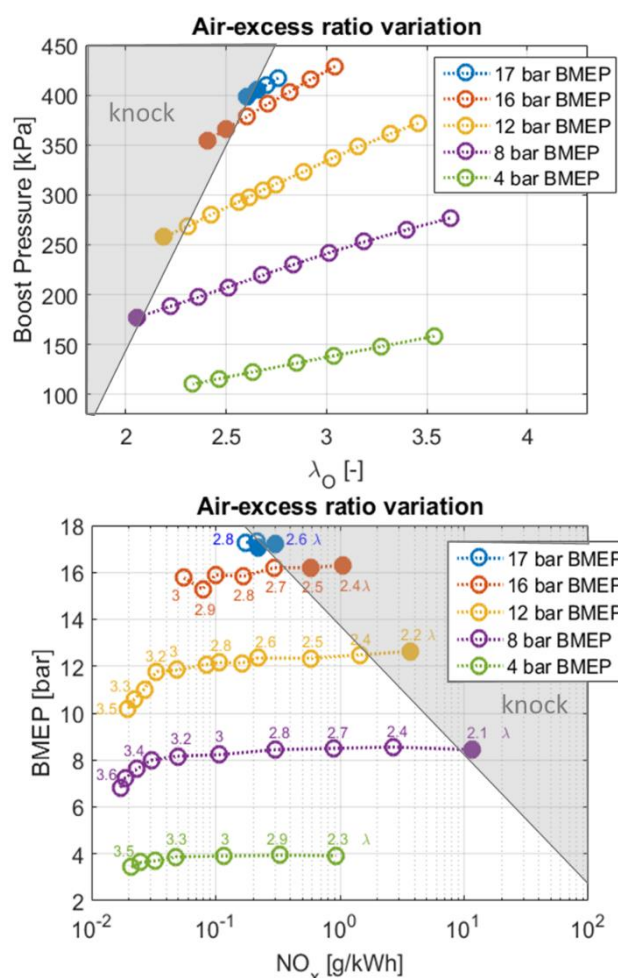


Fig. 1 Top: Required boost pressure for varying air-excess ratio at different engine loads. Bottom: Variation of air-excess ratio at different engine loads. Available operating range for low NO<sub>x</sub> limited by knock and boost pressure. Solid markers indicate points with knocking.

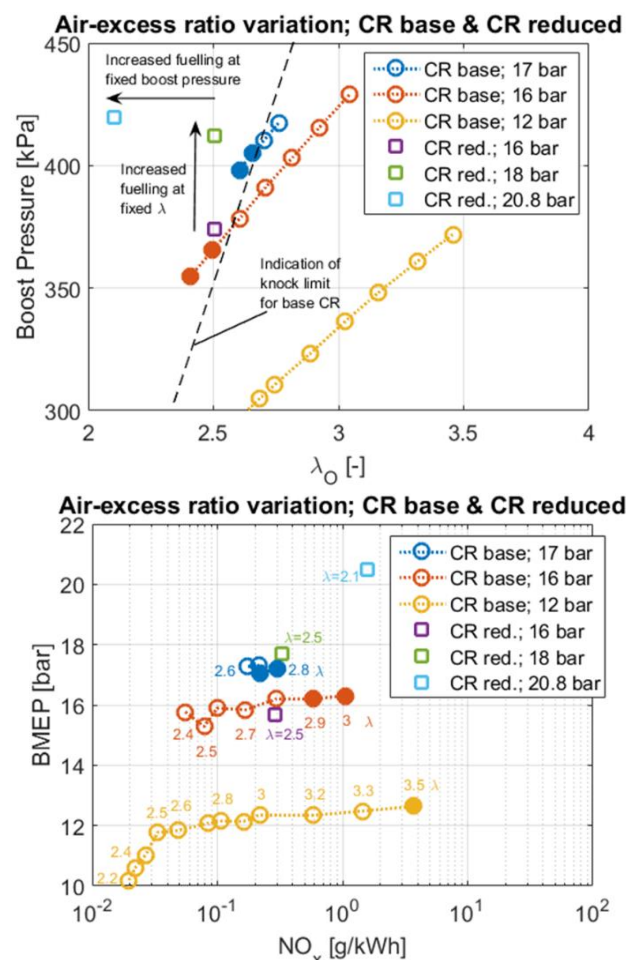


Fig. 2 Top: Impact of reduced Compression Ratio (CR) on available load range by increasing fuelling at 1) fixed air-excess ratio and 2) Fixed boost pressure. Bottom: Impact of increasing the engine load range on engine-out NO<sub>x</sub>. Solid markers indicate points with knocking.