

Experimental H2-ICE study using a heavy-duty single-cylinder setup

- Increasing the load range at low engine-out NOx emissions -

X.L.J. Seykens¹⁾ E. Doosje¹⁾ C. Bekdemir¹⁾

1) TNO, Automotive Campus 30, Helmond, The Netherlands

KEY WORDS: hydrogen, lean burn spark ignition engine, combustion analysis, low NOx emissions, load range

The port fuel injected spark ignited hydrogen combustion engine is considered as an attractive technology for realizing the global CO2 reduction targets. Next to zero CO2 emissions, the lean burn operation also has the potential for low engine-out NOx 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 NOx 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 NOx 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 NOx emissions over a wide load range, see also Fig. 1. Engine-out NOx emissions below 0.02 g/kWh have been observed and NOx emissions remained below 0.2 g/kWh up to 17 bar BMEP. At this load, further NOx reduction is limited by the maximum achievable boost pressure. The load range for low NOx was extended by optimizing the compression ratio and ignition timing, 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 NOx was still low at 1.6 g/kWh.

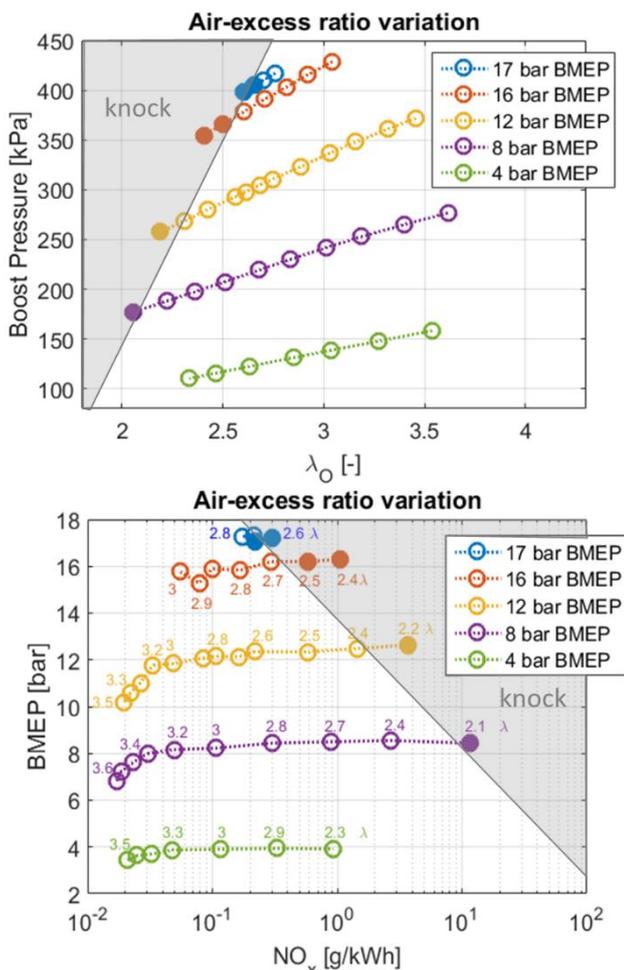


Fig. 1 Top: Required boost pressure for varying air-excess ratio at different engine loads. Bottom: Variation of air-excess ratio at different engine loads. Available operating range for low NOx limited by knock and boost pressure. Solid markers indicate points with knocking.

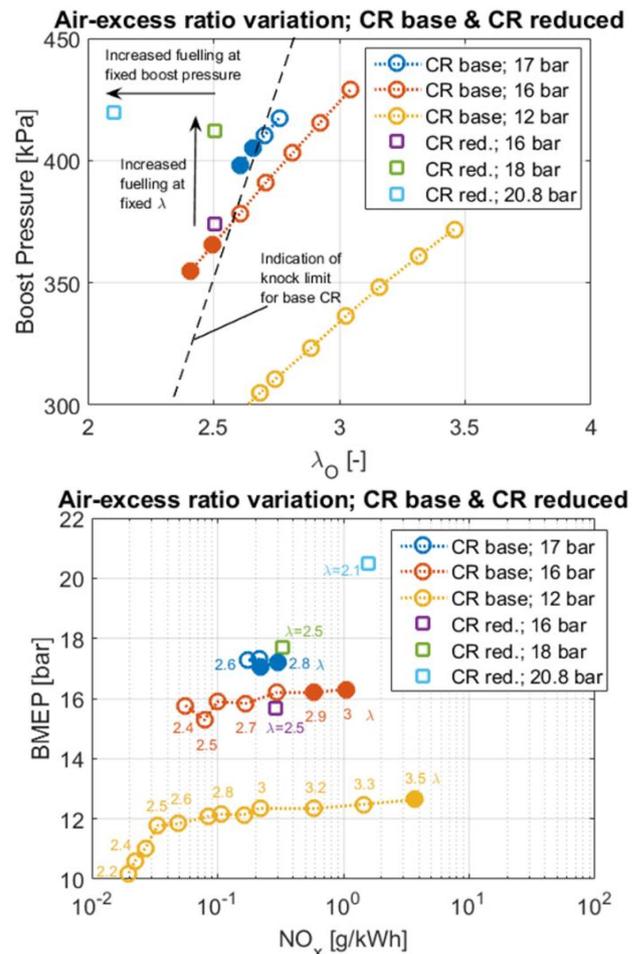


Fig. 2 Top: Impact of reduced Compression Ratio (CR) on available load range by increasing fuelling at 1) fixed air-excess ratio and 2) Fixed boost pressure. Bottom: Impact of increasing the engine load range on engine-out NOx. Solid markers indicate points with knocking.