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Combustion Studies on a Large-Bore Pent-Roof Spark-Ignited Hydrogen Engine

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A hydrogen engine combustion system study was performed on a single-cylinder engine equipped with a high-tumble aluminum pent-roof cylinder head that was previously developed for a natural gas engine demonstration. The study evaluated the impact of tumble ratio and fuel injection method (PFI and low-pressure DI) on indicated efficiency, engine-out NOX, and air flow requirements. Cam phasing was also considered to understand turbocharger limitations for a multi-cylinder engine. The study demonstrated that while low-pressure DI offers the best indicated engine efficiency and reduces intake pressure requirements a reasonable combustion tuning can be achieved with PFI as well. For all configurations, maintaining an acceptable engine-out NOX rate was possible with realistic intake pressures.

Figure 1 shows a pent-roof cylinder head that was designed for previous studies to convert a commercial diesel engine to spark-ignited operation. The cylinder head includes a central direct injector configuration and has been designed with different port geometries to allow for studies on in-cylinder flow details. In this work the cylinder head was installed on a single-cylinder test engine and was operated with both port fuel injection and direct injection of hydrogen to evaluate the combustion details of a medium-duty SI hydrogen engine.

Figure 2 shows an example of the results. In this case the net indicated thermal efficiency is considered with respect to the intake cam phasing advance. The engine was run with port fuel injection and three cylinder head configurations were considered that had different port geometries to change the in-cylinder tumble motion. The results show that the indicated efficiency of the engine was quite high, at up to 45%, and that there were significant differences in the efficiency of the engine with the different heads, showing that the port geometry and in-cylinder flow were important factors in engine performance and efficiency.

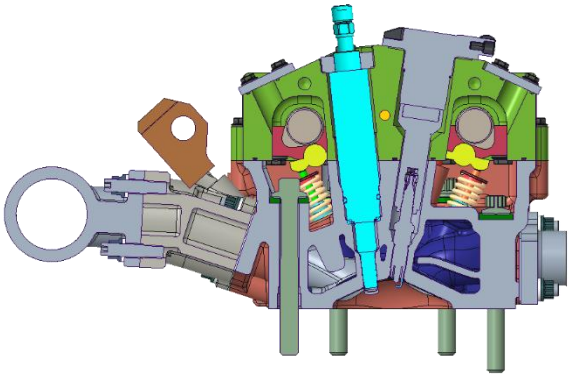

Figure 1 Pent-Roof Cylinder Head Concept Used in Study

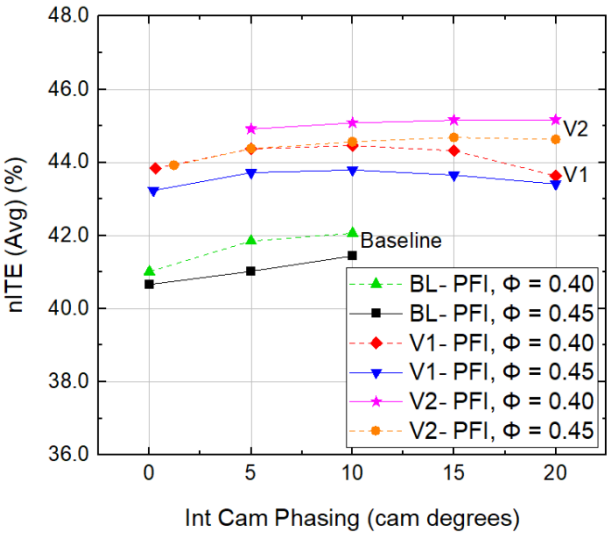

Figure 2 Net Indicated Thermal Efficiency Comparison for Operation with Port Fuel Injection and Three Cylinder Head Configurations