ENERGETICS

FPT Industrial - Advanced Diesel Combustion Optimization for High-Efficiency Heavy-Duty Engines: A Combined Experimental and Simulation Approach

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Context of the research activity	Despite increasing attention on alternative fuels, high-efficiency diesel engines will continue to play a crucial role in heavy-duty transport, particularly in off-road and agricultural sectors, where energy density, robustness, and range remain key constraints. In this context, the development of a new generation of diesel engines — such as the FPT Cursor XC13 platform — requires advanced strategies to minimize both fuel consumption and pollutant emissions, without compromising performance and durability. Achieving this goal requires an in-depth understanding of the combustion process, especially under the demanding conditions typical of heavy-duty applications. To this end, a single-cylinder research engine will be employed at DENERG – Politecnico di Torino, enabling full flexibility in testing and calibration. The single-cylinder platform will allow for precise investigation of the effects of injection strategies, EGR, boost, and combustion chamber geometry on thermal efficiency and emissions. Numerical simulations based on 1D and 3D CFD tools will be used in synergy with experimental campaigns to reduce development time and cost, while ensuring a physics-based interpretation of the observed phenomena. The lack of a detailed, predictive, and validated simulation framework for modern heavy-duty diesel combustion — tailored to next-generation engines like the XC13 — represents a significant gap that this project aims to fill.

	The main objective of this PhD research is to support the development of highly efficient and low-emission diesel combustion systems for next-generation heavy-duty engines through a combined experimental and numerical approach. Specific goals include: • Development and operation of a flexible single-cylinder engine platform, representative of the XC13 architecture, for systematic testing of combustion strategies; • High-fidelity experimental characterization of in-cylinder pressure, heat release rate, emissions, and performance over a wide range of operating conditions;

Objectives	• Implementation and validation of CFD combustion models (in tools such as CONVERGE CFD), incorporating detailed spray, ignition delay, and pollutant formation sub-models; • Use of 1D tools (e.g., GT-Power) to support full engine cycle modeling, transient response, and turbocharging strategies; • Optimization of combustion phasing, injection profiles, and air management to identify trade-offs between efficiency, NO¿, soot, and combustion noise; • Calibration of virtual tools for predictive use in engine development, reducing the need for extensive test bench iterations. This integrated methodology will contribute to the creation of robust design guidelines for the development of clean and efficient diesel engines in compliance with upcoming emission regulations.

Skills and competencies for the development of the activity	• Excellent knowledge of fluid-dynamics and engine thermodynamics • Knowledge of 1D/3D CFD simulation codes (such as GT-SUITE, CONVERGE CFD)