PhD in Energetics

Research Title: Study of Ultra-low NOx Diesel Combustion Systems by Synergetic Application of 3D-CFD and Single-Cylinder Engine

Funded by	General Motors Global Propulsion Systems

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Context of the research activity	The research activity, which will be funded by General Motors Global Propulsion Systems (GM hereafter), will be carried out in the framework of the partnership agreement between Politecnico di Torino and GM. The increasingly demanding targets in terms of CO2 reduction and the more stringent emission regulations are pushing the OEMs to the adoption of engine technologies left so far for innovation. Looking forward to next years, a not negligible increase in Diesel engines cost to meet the CO2 targets is expected, with a significant impact on market penetration in the near future. But Diesel engines are going to cost more and more not only because of CO2 emission targets, but also because of pollutant emission limits. In order to fully exploit the potential of the abovementioned innovative technologies, numerical simulation can play a fundamental role by allowing the creation of a kind of a virtual test rig where evaluating the impact of design modifications.In this scenario, the question moves to the source of the problem: is it possible to further reduce diesel engine pollutant emissions and CO2 emissions, by directly acting on the combustion process within the combustion chamber? To answer this fundamental question the research program will investigate, through both 3D-CFD simulation and experiments on a single cylinder engine, the potential of innovative combustion systems to reduce engine-out pollutant emissions and fuel consumption for next generation of automotive diesel engines.

Objectives	The research program is aiming to contribute to the development of a new generation of low emissions automotive diesel engines, through the creation of CFD models capable to provide a "virtual test rig" for the optimization of the gas exchange process, of the fuel injection process, of the mixture formation and combustion processes, in order to minimize pollutant emissions (especially NOx and Particulate Matter) while maximizing the efficiency of the energy conversion process. To this aim, the potential of innovative combustion systems such as "Wave", "Twin Vortex" and "Stepped lip" will be carefully scrutinized first by means of the abovementioned "virtual test rig" and then through experimental investigations carried out on a single cylinder engine. The PhD activity will be carried out mainly at the Advanced Internal Combustion Engines Lab at the Energy Department of the Politecnico di Torino. The main research activities which the PhD Candidate will carry out are the following: 1. Analysis of innovative piston bowl designs such as "Wave", "Twin Vortex" and "Stepped lip". 2. Combustion chamber optimization by means of DoE (Design of Experiments) and Genetic Algorithms techniques applied to the numerical models previously developed for the geometries identified by task #1. 3. Characterization of the performance of the optimal designs identified by means of the previous task #2 for different calibration parameters such as boost and swirl level, injection pressure and injection schedule. 4. Assessment of the most promising designs previously identified through a dedicated experimental campaign carried out on a single cylinder engine. Additional sub-objectives will be: • Publications of at least one technical paper in a high-impact peer-reviewed international journal. The break-down of the activities will be the following: • Extensive literature review on innovative combustion chamber designs (6 months). • Development of multi-physics models to analyse and improve the most promising combustion systems (1,5 year). • Experimental activity on a Single-Cylinder Engine (6 months). • Thesis and scientific papers writing (6 months). **Refs & Presentation @ International Conferences:** **[1]** Eismark, J., Andersson, M., Karlsson, A., Denbratt, I., "Reduced Soot Emissions by Piston Bowl-Shape Guided Late Cycle Oxidation in Low-Swirl Heavy-Duty Diesel Engine Combustion," at SIA Powertrain 2018, May 16, 2018, Rouen, France. **[2]** Eismark, J., Andersson, M., Christensen, M., Karlsson, A. et al., "Role of Piston Bowl Shape to Enhance Late-Cycle Soot Oxidation in Low-Swirl

	Diesel Combustion," SAE Int. J. Engines 12(3):2019, https://doi.org/10.4271/03-12-03-0017. **[3]** Bianco, A., Millo, F., Piano, A., and Sapio, F., "Numerical Assessment of an Innovative Piston Bowl in a Light-Duty Diesel Engine," Proceeding of the 2019 European CONVERGE User Conference, March 13, 2019, Barcelona, Spain. **[4]** Bianco, A., Millo, F., Piano, A., and Sapio, F., "Assessment of Innovative Bowl Geometries over Different Swirl Ratios/EGR Rates," Proceeding of the 2018 European CONVERGE User Conference, March 19, 2018, Bologna, Italy.

Skills and competencies for the development of the activity	• Excellent knowledge of engine thermodynamics. • Matlab programming. • Knowledge of 3D/1D CFD simulation codes (such as CONVERGE CFD, GT-SUITE) would be a plus.