ENERGETICS

DM630/Dumarey-Direct H injection simulation improvement & development of Reduced Order Models for coupling with in-cylinder combustion numerical tools

Funded By	MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584] DUMAREY AutomotiveItalia S.p.A [P.iva/CF:09075820010]
Supervisor	FERRARI ALESSANDRO - alessandro.ferrari@polito.it
Contact	FERRARI ALESSANDRO - alessandro.ferrari@polito.it NOVARA CARLO - carlo.novara@polito.it VENTO OSCAR - oscar.vento@polito.it Cozza Ivan
Context of the research activity	The research activity consists in developing reduced order models of 3D numerical models for the direct injection of hydrogen in innovative internal combustion engines. The developed simulation tool with the reduced order model for hydrogen direct injection will be then integrated in a complete existing numerical model of the hydrogen engine, which also includes combustion and pollution species formation. Progetto finanziato dal PNRR a valere sul DM 630/2024 - CUP E14D24002370004
	The research on internal combustion engines fuelled with hydrogen is consistent with the decarbonisation objectives of the European Community, as well as capable of enhancing and relaunching, with innovative projects, the skills of local companies relating to the sector of thermal propulsion systems for land traction with the training of highly professional profiles qualified. In particular, the direct injection technology makes it possible to reduce or eliminate some hydrogen combustion anomalies (such as backfiring, pre-ignition and knock) and improve the engine efficiency, while at the same time drastically reducing NOx emissions and virtually eliminating CO2 emissions. The current investigation, which is mainly of numerical type, will initially focus on the improvement of existing 3D models of underexpanded hydrogen, directly injected in the engine cylinder and characterized by the presence of Prandtl-Meyer expansion and Mach disk occurrences. Such numerical models are complex because can require advanced finite volume techniques

Objectives	(such as flux difference splitting and flux vector splitting), which are usually developed for 1D convective unsteady flows and therefore require suitable extension to multidimensional and diffusive unsteady flows. Therefore, spatial and temporal accuracy are quite onerous in terms of computational efforts, especially when carrying out series of simulations to optimize the engine design. However, once 3D models of hydrogen direct injection have been validated against experimental results coming from optical tests of the H2 jet, reliable datasets can be generated to develop Reduced Order Models (ROMs), based on Machine Learning methods in the context of Artificial Intelligence (AI). The objective is to to realize an efficient numerical tool, consisting of a ROM of the direct injection process that is capable of interfacing with an existing simulator of the entire engine operating cycle. The latter simulator can even predict combustion evolution and pollution formation. The complete model of the direct injection hydrogen engine will be validated with experimental data made available by Dumarey, which is the industrial company that cooperates with Politecnico in this project.

Skills and competencies for the development of the activity	Background in applied physics, fluid dynamics and numerical analysis is required. The candidate should also have basic knowledge of mechatronics and machine learning methods in order to be able to realize accurate reduced order models. Furthermore, the ability to develop home-made codes (wriiten in Matlab or C languages) is recommended . Finally, the inclination to work in a team is fundamental since the candidate will interface with the research group who developed the existing 3D models.