Politecnico di Torino

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AEROSPACE ENGINEERING

Direct Hydrogen Combustion in Jet Engines

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	The aim of the research is to evaluate benefits and face challenges due to the direct burning of hydrogen in modified gas turbine aeroengines. After

Context of the research activity	investigating engine performance, design and operational matters of interest when using hydrogen, attention is paid to direct hydrogen combustion, combustor preliminary design and performance evaluation.

	The present research refers to the goals included in CN4 - Sustainable mobility . The effect of aviation emissions on human-induced climate change has become a major concern in the last decades. Aircraft should be less polluting, less noisy and more fuel efficient. The expected reduction of CO2 emission an NOx emission identified by ACARE in Europe are very challenging. Current incremental technological improvements appear not to be able to achieve these targets and different breakthrough technologies have been proposed. Direct hydrogen combustion in modified jet engines is one of them (e.g. see Airbus ZEROe Concepts). In fact, the use of hydrogen as an aircraft fuel has tremendous environmental benefits over current systems with the elimination of carbon monoxide (CO), carbon dioxide (CO2), sulfur oxides (SOx), unburnt hydrocarbons (UHC), and smoke. Nevertheless, high temperatures and high flame speeds introduces new issues wrt hydrocarbon fuels. Burning hydrogen in diffusion mode produces large quantities of NOx due to the high flame temperatures. Since H2 has larger flammability range wrt hyrodcarbon fuels, lower equivalence ratios with possible reduction of NOx emission. Thus, the development of lean premixed hydrogen combustors for gas turbine aero engines can reduce not only greenhouse emissions, but also oxides of nitrogen. Unfortunately, lean premixed flames have been susceptible to experiencing problems with stability, caused by different mechanisms. For instance: flashback due to turbulent flame speed may exceed the average upstream velocity (high average velocities determine high pressure drops thus reducing engine performance). Different approaches are then under development. Goals of the program are to analyze benefits of direct hydrogen combustion, facing up with combustor design challenges.
Objectives	Tasks will include:

	1) SOA – literature survey (pervious/existing programs, H2 direct combustion, H2/air reaction mechanisms….) 2) Definition of a reference case 3) Identify possible engine performance issues when using hydrogen 4) Analyze and compare proposed approaches to H2 direct combustion, identifying most relevant design parameters, restrictions and constraints 5) Preliminary design of the combustor, and performance evaluation 6) Preliminary optimization through Machine learning approaches 7) Dissemination activities

Skills and competencies for the development of the activity	Aircraft Propulsion – Combustion – Combustion instability – Programming skills – CFD experience – Machine learning background