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Humidification towards flashback prevention in an original H_2 fueled micro Gas Turbine combustor -- 0D/1D predeterminations and LES validation

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Hydrogen (or hydrogen enriched methane) combustion is well-known to lead to flame instabilities, and potentially resulting in flashback apparition. In this framework, combustion air humidification is considered to stabilize hydrogen combustion, and to avoid flashback apparition in a micro Gas Turbine without having to redesign the combustor. Using a hybrid model, combining a 0D Chemical Reactor Network and 1D Laminar flame calculations, the laminar flame speed is evaluated at reduced cost to predetermine the necessary minimal water dilution of the combustion air to avoid flashback for several CH4/H2 blends. The predefined operating conditions are then tested and validated using high fidelity Large Eddy Simulations of the actual combustor geometry of the T100 mGT. In addition, an Adaptive Mesh Refinement method is implemented in the LES code to perfectly capture the flame front

The 0D/1D simulation results show that the combustion, at nominal operating conditions of the Turbec T100 fueled with different CH4/H2 blends (25/75, 50/50, 75/25 and 100/0%), can indeed reach the same level of flame speed as pure methane combustion by humidifying the combustion air (using a water-to-air ratio of 1.5, 3.4, 5.9 and 10.25% respectively). Moreover, the 3D LES simulation results confirm these observations, by showing stable combustion for these predetermined levels of humidification. Similar temperature and reaction rate levels of to those of pure methane combustion are reached in the combustor. Therefore, the 0D/1D approach provides accurate, and low cost, predetermination of the operating parameter to avoid flashback apparition.