MODELLING OF FURNACES AND COMBUSTION SYSTEMS

(685) - (*) - NUMERICAL STUDY OF THE EFFECTS OF GLOBAL EQUIVALENCE RATIO ON TURBULENT SWIRLING NON-PREMIXED FLAME

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This work investigates numerically a non-premixed swirling flame provided by a coaxial burner with radial fuel injection under lean and rich conditions. The burner configuration consists of two coaxial tubes with a swirler placed in the annular part. The radial injection of methane is provided through eight holes symmetrically distributed on the periphery of the central tube. The experiments are conducted in a combustion chamber of 25 kW power and 48x48x100 cm^3 dimensions using circulating water as coolant. Six windows are arranged in each face of the chamber allowing optical access to the entire length of the flame. All Simulations are carried out using the ANSYS-Fluent CFD code. The turbulence is captured using the Reynolds Averaged Navier-Stokes (RANS) approach. Chemistry/turbulence interaction is resolved using the Eddy Dissipation Model. Simulations are performed with various global equivalence ratios (1.3, 1.2,1, 0.8 and 0.5). Model validation is achieved by comparing obtained computed results to experimental data in the case of the stoichiometric regime. RANS is accompanied with detailed Stereoscopic Particle Image Velocimetry (Stereo-PIV) measurements to analyze the dynamics of non-premixed swirling flows under non-reactive and reactive conditions. Good agreement between numerical results and experimental measurement is reported. The central recirculation zone (CRZ) and the swirling jet region (SJ), due to the presence of the swirl, are well predicted by the simulations. The effect of the global equivalence ratio on the profile of axial velocity, tangential velocity, turbulent kinetic energy (TKE), temperature distribution and pollutant emissions (CO and NOx) are numerically studied. From dynamic point of view, the equivalence ratio modifies the mean axial and tangential velocity of the swirling diffusion flame. TKE results show that the quality of the mixture between the fuel and the oxidizer depend on the global equivalence ratio. Decreasing the equivalence ratio favor the flame stability by reproaching the flame to the burner exit. NOx formations increase with the decrease of global equivalence ratio.

Palavras-chave : equivalence ratio, swirling flame, non-premixed combustion, coaxial burner, numerical simulation