Session:

Computational Investigation of a Swirled Premixed Burner Using Hybrid RANS-LES method

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1 Introduction

Swirling flows are commonly used in modern gas turbine combustors to promote the flame stabilization and reduce pollutants emissions. Vortex breakdown that presents near the burner exit is a unique feature that characterizes the swirling flow. It leads to the formation of a central recirculation zone (CRZ), which puts the burned gases and the unburned reactants in a permanent mixing. The CRZ is commonly associated with stagnation points and those often accompanied by the occurrence of coherent precessing vortex core (PVC) [1].

In this work the unsteady three-dimensional flow of a premixed-swirled propane flame in a model burner is studied numerically. Turbulence-chemistry interaction is treated using Detached Eddy Simulation (DES) turbulence model [2] and Finite-Rate/Eddy Dissipation (FR/EDM) combustion model [3]. The computations were done using ANSYS-Fluent 14.0 CFD software package. The model vortex burner of Anacleto et al [4] used in this work consists of a swirl generator, premixing tube and a cylindrical combustion chamber. In the burner, the flame operates with a perfect mixing of propane and air, for an equivalence ratio $\Phi = 0.5$ at the atmospheric pressure. The unburned gas temperature at the inlet is T_0=573 K and the flow rate of the mixture is m_{mix}=46g/s. Validations of the computational models with the experimental data are performed and a good agreement is found. It is found that the unsteady flow contains a large-scale coherent PVC with double structure. Furthermore, phase-angle analysis of the instantaneous flow field shows the presence of unsteady stagnation points strongly associated with PVC.

Session:

2 Results

The 3D flow structure in figure 1(a) is found completely asymmetric, and it contains different eddies with different sizes and forms. The snapshot reveals two large-scale spiral vortices denoted here PVC and OSV. The PVC is found to be a double helix structure.

Figure 1(b) shows a comparison between Laser Doppler Velocimetry (LDV) and thermocouples measurements and present numerical results of the radial profiles of time-averaged axial velocity and progress variable of temperature. It is clearly shown that the DES method presents very adequate predictions of the flow properties profiles in all locations.

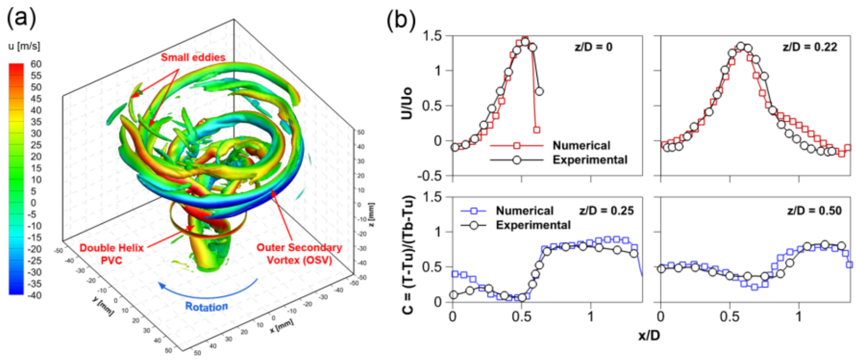

Fig. 2 3D flow structure (a) and validation with measurements (b)

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