Impact of Preheated Central Jet on Intermixing of Confined Multi-Annular Swirling Jets

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1. INTRODUCTION & OBJECTIVE

Efficient mixing of air and fuel within the gas turbine combustor is essential requirement for stable combustion and flame stability. However, in multi-annular configurations, the addition of an extra annular jet increases shear layer interactions between the jets, which enhance mixing within the confinement [1-2]. Swirling flows are widely employed in combustor design because they enhance turbulence, promote large-scale recirculation zones, and stabilize the flame. Mixing of coaxial swirling jets in confinement has been investigated experimentally and numerically over past decades. There is comparatively limited understanding of confined multi-annular jet configurations, especially under the combined influence of swirl, confinement, and thermal effects. The present study examines the flow and mixing behavior of a configuration featuring three swirling air jets: one central jet and two annular jets. This investigation is conducted in two scenarios: expanded confinement with an expansion ratio of 1.8 and non-expanded confinement with an expansion ratio of 1. The central jet, which represents the fuel jet, is analyzed under two conditions: one that is non-heated at 300 K and another that is preheated at 473 K. The main objective is to evaluate how heating the central jet affects the formation of recirculation zones and the decay of axial velocity, both of which are essential indicators of mixing performance.

2. METHODS OF ANALYSIS

The investigation is conducted through computational fluid dynamics (CFD) simulations using ANSYS Fluent. A two-dimensional axisymmetric domain is employed to model the confined flow field. The central jet and the two surrounding annular jets are treated as air jets. Swirl is imposed on each jet; the swirl number(s) for the central jet is 0.385, and the inner and outer annular jets are 0.470 and 0.478, respectively

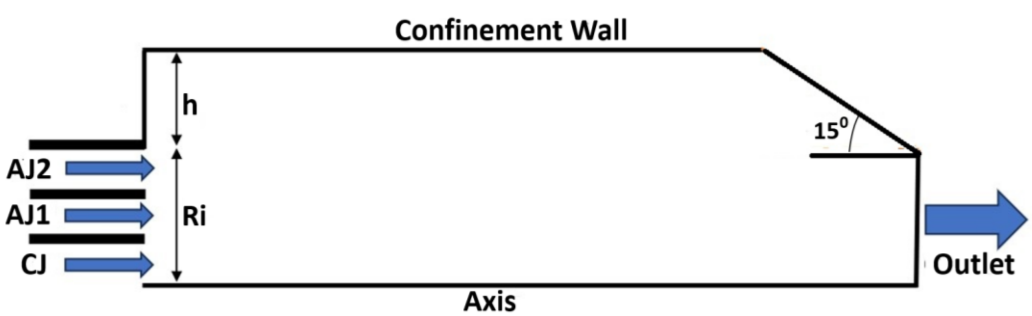

Figure 1. Geometry details 2D axisymmetric multi-annular confinement [3].

The realizable k-ε turbulence model is adopted for turbulence closure. This choice was based on a validation exercise in which numerical results were compared with existing experimental data reported in the literature for confined swirling jets.

3. RESULTS

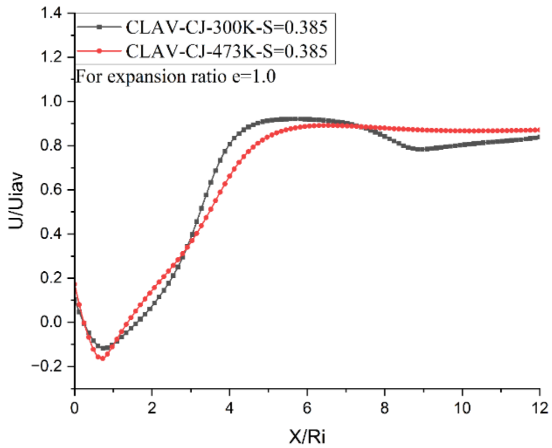

Figure 2. Central line axial velocity for expansion ratio e=1.0

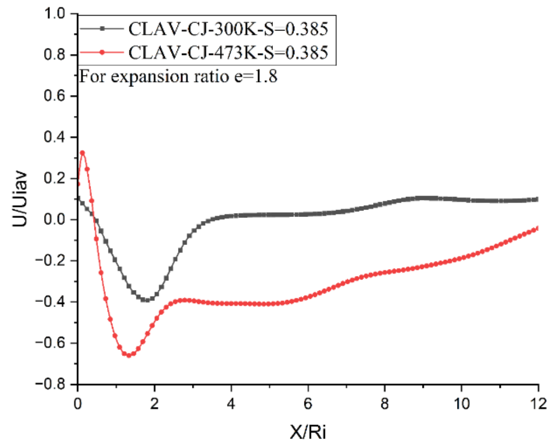

Figure 3. Central line axial velocity for expansion ratio e=1.8

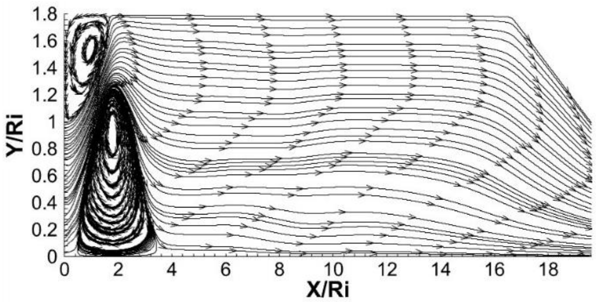

Figure 4. Central recirculation zone for expansion ratio e=1.8 with non-heated central jet

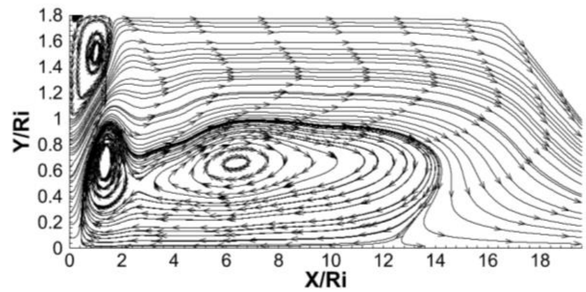

Figure 5. Central recirculation zone for expansion ratio e=1.8 with heated central jet

4. CONCLUSIONS

Figures 4 and 5 illustrate that preheating the central jet leads to an enlargement of the recirculation zone, while Figures 2 and 3 demonstrate an accelerated decay of the centerline axial velocity for both expanded and non-expanded confinements. Both of which are indicators of improved mixing performance.

5. REFERENCES

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