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# Computational and experimental investigations of turbulent asymmetric vortex flames ☆

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ABSTRACT

In the present article we present computational and experimental investigations of a turbulent asymmetric vortex flame. Such flame was created in a novel asymmetric combustor, which is described for the first time in this article. The three dimensional isothermal and reacting flow fields have been described using a computational methodology that impalements the $R_\varepsilon/k-\varepsilon$ and the eddy dissipation turbulence and combustion models, respectively. The computational model is validated for both isothermal and reacting flows. Additionally, the visible flame structure was captured by direct photography at a wide range of equivalence ratios in order to emphasize the exceptional stability of such flame. The mechanism of flame stability and interaction with the forced vortex field is preliminarily discussed. Finally, the basic characteristics of the asymmetric vortex flames are concluded.



## 1. Introduction

The first discussion of vortex flames was reported in 1998 by Gabler in [1]. The turbulent vortex flame was described for the first time in such work by both experimental and computational methods. The major objective of Gabler's work was to identify the possible reduction in pollutant formation from vortex flames. A concise description of the flame anatomy was presented, and some of the basic features of vortex flames were reported. These features include the enhanced stability near to the lean flammability limit of the fuel, and some primary temperature profiling. The vortex flame of Gabler was created by injecting air through a tangential port in a cylindrical combustor. The combustor used in [1] is illustrated in Fig. 1.

In the experiments of Gabler [1], when the axisymmetric fuel inlet was used, the resulting flame demonstrated the characteristics of conventional swirl-stabilized flames. However, when the asymmetric fuel inlet was used, the resulting flame had absolutely different characteristics than swirl-stabilized flames. The first difference is that the asymmetrically fueled flame had a substantially reduced length. The second difference is the blue color of the flame, which practically characterizes premixed flames [2]. The third difference is the flame stability. It was reported that such asymmetrically fueled flame has an increased range of stability compared to conventional swirl-stabilized flames, especially near to the lean equivalence ratio. The fourth difference is the ultra reduced levels of NO and NOx emissions.

The term *asymmetric* was coined by Gabler to express the location of the fuel inlet port with respect to the geometrical axis of the combustor [1]. However, in the present work, the term *asymmetric* is proposed to express two configurations; first is the isothermal and reactive flow fields of the vortex flame and second is the geometry of the novel combustor described in this article. In the present work, the term *vortex* replaces the term *whirl* used by Gabler to express the

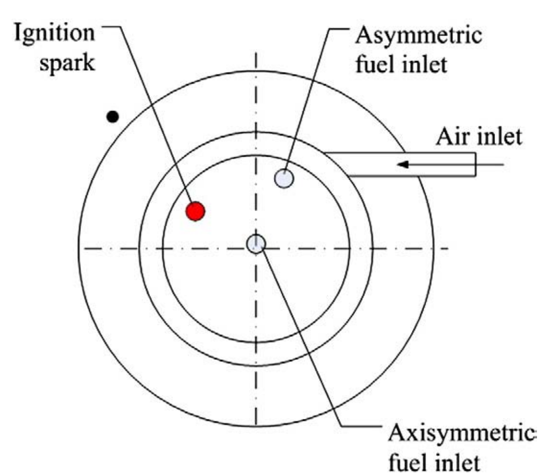


**Fig. 1.** Schematic of the asymmetric vortex combustor reported by Gabler in [1].

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