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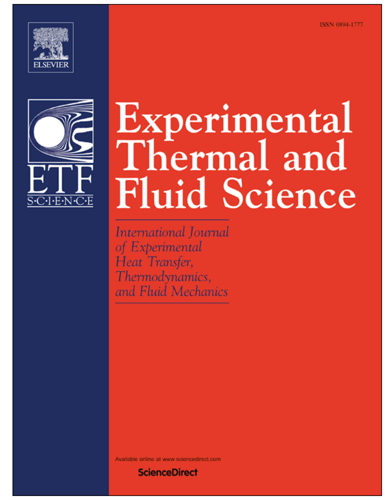

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Characteristics and mechanism of mixing enhancement for noncircular synthetic jets at low Reynolds number

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ABSTRACT

In this paper, the evolution of flow structures and the mixing characteristics in low-aspect-ratio (AR) noncircular incompressible synthetic jets are investigated. Two elongated configurations, elliptic and rectangular orifices with AR = 3 and 5 are used to produce synthetic jets at a Reynolds number of 166. The velocity fields in different spatial planes are measured by time-resolved two-dimensional particle image velocimetry (2D-PIV), and stereoscopic PIV (S-PIV), respectively. The results show that the evolution of vortical structures and the flow physics are influenced by the orifice configuration and AR. The first axis-switching location of the elliptic cases is closer to the jet orifice than that of the rectangular cases, while the AR = 3 cases undergo more upstream location and more times of axis switching than the AR = 5 cases. In addition to axis switching, noncircular synthetic jets are observed to develop streamwise vortices. The rectangular cases develop stronger streamwise vortices than the elliptic cases. The extended angle of streamwise vortices increases with the increasing AR, and is larger for the rectangular cases than the elliptic cases. In particular, the AR = 3 rectangular case has larger values of centerline streamwise velocity fluctuation, Reynolds stresses, mass flow rate and momentum flux than the other cases in the second axis-switching region, suggesting significantly enhanced mixing and momentum transportation characteristics. The mechanism could be attributed to its more evident vortex deformation and stronger streamwise vortices.

Keywords: Elliptic synthetic jets; Rectangular synthetic jets; Aspect ratio; Low Reynolds number; Axis switching; Mixing

1. Introduction

Active or passive jet control techniques have been widely applied to solve numerous engineering problems such as heat transfer, combustion and noise suppression [1-4]. The mixing characteristics of jets are of fundamental importance to affect their performance in these aspects. Effective entrainment and mixing enhancement could be achieved by altering the evolution of flow structures accompanying with jet development.

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