ABSTRACT

Piezoelectric synthetic jet actuators have shown great potential in practical application as active flow control devices due to the advantages of light weight and high efficiency. During the operation, the synthetic jet flow has the cycle-averaged property of zero-net-mass-flux but nonzero momentum flux. The purpose of this study is to probe the compressible turbulent synthetic jet flow characteristics for a dual diaphragm piezoelectric actuator. In the experimental investigation, a flow visualization system was established to obtain the particle streak images with 10-μm red fluorescent spheres for the piezo-driven synthetic jet flowfield, produced by a dual-diaphragm piezoelectric actuator. In operation, the piezo diaphragms of the actuator were simultaneously driven by a sine waveform. A 5W argon- ion laser with a cylindrical lens was employed to illuminate the flowfield in the cross-sectional plane. The streakline scattered from the fluorescent particles was photographed using a charge-coupled device (CCD) camera. The centerline velocity of the synthetic jet was measured using a hot-wire anemometry system for the code validation. A computational approach also adopted the transient three-dimensional conservation equations of mass and momentum with the moving boundary specified to represent the piezo diaphragm motion. The k-e two-equation turbulent model was used for turbulence closure. The particle streakline images in the cross-sectional plane at the resonant frequency of 648 Hz obviously visualized a fully-developed turbulent jet flow pattern in the far-field area. The close view photograph revealed the time-periodic formation and advection of discrete vortex pairs. The hot-wire anemometry results showed that the measured centerline velocity of the synthetic jet reached 3.8 m/s at y/d= 50. The numerical simulation indicated that the near-field flow tended to undergo transition to turbulence. In addition, the orifice fluid was entrained into the actuator cavity due to the outward movement of the piezo diaphragms when the vortex pairs were sufficiently distant away from the orifice.


