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Jet Direction Control Using Active Switching Nozzle

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Extended Abstract

Many studies have been conducted on fluidic thrust vectoring, which uses a secondary flow to deflect a primary jet, instead of mechanical thrust vectoring including a variable exhaust nozzle, to improve maneuverability and maintainability by simplifying, downsizing, and reducing the weight of the entire thrust vectoring system [1]. In recent years, research has also begun on the utilization of synthetic or hybrid-synthetic jets as secondary flows for further increasing the deflection angle [2]. In addition, Mair et al. [3] proposed a novel fluidic valve with active switching using acoustic signals and a splitter; they determined the flow switching mechanism from experimental and numerical results. These technologies find applicability in not only aircraft development but also in a wide range of other fields, including heating, ventilation, and air-conditioning systems. However, in the conventional methods, there is a dead zone where the deflection angle cannot be adjusted, and a technique to adjust the deflection angle precisely without a splitter, which is an issue in practical use, has not been established.

Therefore, in this study, the control of the direction of the generated flow using a new active switching nozzle in which the face-to-face control port portion of a conventional flip-flop jet nozzle was replaced by compact speakers that can be adjusted to any frequency, oscillation amplitude, and phase difference, was studied experimentally. The geometry of the tested nozzle was fabricated with reference to the flip-flop nozzle of Koso et al. [4]. The influence of the spread angle of the side wall of the duct, where the continuous jet fed inside the tested nozzle attaches and detaches periodically owing to the oscillation of compact speakers, on the deflection angle of the generated flow was investigated experimentally. The velocity fields inside and downstream of the tested nozzle were measured by a hot-wire anemometer and two-dimensional particle image velocimetry to investigate the vorticity distributions and the deflection angle of the generated flow. Computational fluid dynamics assuming a two-dimensional incompressible viscous flow was also performed, with unsteady Reynolds-averaged Navier-Stokes as the governing equation, to supplement the experiments. The results obtained show that the relationship between the spread angle of the expanding duct and the oscillation frequency and amplitude of the continuous flow inside the nozzle affects the deflection angle of the generated flow.

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