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Jet Vectoring by Suction Flows on Surface of Circular Cylinder

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Extended Abstract

For indirect blowing in thermal management or ductless ventilation, it is necessary to establish a technique for rapid deflection of the jet stream. Jet vectoring technique has been studied in the past, and recently, the interest in fluidic thrust vectoring, which controls the direction of the jet flow without changing the geometry, has considerably increased. Maison et al. [1] reported that the thrust vector coefficient in the deflection of the primary jet depends on the momentum ratio of the primary and secondary jets. When the jet deflection angle is adjusted by the momentum ratio, it is classified into three regions: dead zone, controllable region, and saturated region. Later, Kobayashi et al. [2] and Zhang et al. [3] reported that the jet deflection angle can not only be adjusted by the momentum ratio but also by the dimensionless frequency using a synthetic jet and hybrid synthetic jet as the secondary jet, respectively. However, in most previous studies, the jet deflection was controlled by a single slot for the secondary flow, and the maximum deflection angle achieved was less than 90°, indicating that the discussion of the maximum deflection angle was not sufficient.

In this study, a fluidic thrust vectoring method, with multiple slots on a Coanda surface, was proposed to expand the jet deflection angle. Five secondary slots for steady suction were installed on the Coanda surface at 30° intervals to control the direction of the primary jet. The Coanda surface radius ($R = 2.5 \times 10^{-2}$ m), primary jet slot width ($h_1 = 1.0 \times 10^{-2}$ m), secondary jet slot width ($h_2 = 2.0 \times 10^{-3}$ m), primary jet flow velocity ($U_1 = 10\ \mathrm{m/s}$), and secondary jet flow velocity ($U_2 = -5\ \mathrm{m/s}$) were kept constant, and the combination of secondary slots to be operated was investigated through numerical simulation, experimental flow visualization, and velocity distribution measurements. Numerical simulations were performed using the ANSYS Fluent 2021 R1 software (ANSYS Inc.). The experiments were conducted using a hot-wire anemometer (Smart CTA 720), I-type probe (KANOMAX 0251R-T5), parallel probe (KANOMAX 0247R-T5), and digital camera (Sony Corporation ZV-1). The results show that the suction from multiple slots on the Coanda surface reduced the pressure on the cylindrical surface and suppressed jet detachment, resulting in an extremely large jet deflection angle. Moreover, the direction of the primary jet could be controlled by changing the combination of the secondary slots to be operated. Conditions under which the maximum deflection angle reaches approximately 180° were found, and it was possible to control the direction of the primary jet by changing the combination of secondary jet slots, such as the first slot at $\beta = 30°$, second slot at $\beta = 60°$, and fourth slot at $\beta = 120°$, on the cylindrical surface. Combinations of slots were also found for achieving minimum suction flow (approximate 30% of the primary jet flow) by skipping one slot at a time instead of sequentially operating the slots.

References

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