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Characteristics of Oscillations Induced At Downstream Of A Circular Cylinder with Tangential Blowing For Jet Vectoring

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Extended Abstract

Attempts have been made to apply tangential blowout cylinders, a type of circulation control wing, to control flow direction [1]. In previous studies, the effects of the installation angle of the blowout slots in the cylinder and the momentum of the jet sheet on the flow characteristics were discussed. The pressure distribution on the surface of the cylinder and the transition of the separation point were also clarified in relation to the aerodynamic characteristics. [2]. It is well known that when a circular cylinder is placed in a flow, the so-called Kalman vortex, in which periodic vortex ejections are repeatedly generated from the cylinder, is one of the most famous self-excited oscillations in fluid dynamics. Some studies have been conducted on the oscillatory characteristics of wake flow with other geometries [3]. Although there are conditions under which the Kalman vortex can be generated in the backwaters of tangential blowout cylinders, there have not been many studies focusing on the vibration characteristics that occur downstream of tangential blowout cylinders [4],[5], and the knowledge obtained so far is limited. In particular, the relationship between the behavior of the jet sheet and the dead water region formed behind the cylinder as well as the relationship between the dead water region and frequency remain unclear.

In this study, we focused on the vibration characteristics of the self-excited oscillations that occur when a tangential-blowout cylinder is used to control the direction of the jet flow. Velocity fluctuation measurements were performed mainly on the jet sheet ejected from the surface of the cylinder, the size of the dead water region formed behind the cylinder, and the frequency at which the Karman vortex is generated. In this study, the primary jet flowed from a wind tunnel height of $S=$ 200 mm and widths of $W=50$ mm or 200 mm. Experiments were conducted 200 mm downstream from the wind tunnel outlet with a tangential blowout cylinder with a cylinder diameter $D=200$ mm, a cylinder span length of 200 mm, and the width of a slot outlet of 1 mm at a slot installation angle of $\theta_j=90°$. The main parameters were momentum coefficient C_μ for the momentum of the jet from the slot, $U_p=8.3$ m/s for the main flow velocity, and $Re=2.7\times10^4$ for the Reynolds number.

The main results show that under the condition $W/D=4$, where the primary jet width is relatively wide, the dead water region shrinks as the momentum coefficient C_μ increases, and correspondingly the Strouhal number increases slightly. In addition, above a certain momentum coefficient C_μ, no clear peak in the spectral distribution is observed and the Karman vortex is suppressed. The suppression of oscillations above a certain C_μ is consistent with the results obtained by Okayasu et al. in uniform flow [2]. For $W/D=1$, where the primary jet width is relatively narrow, there is little change in the size of the dead water region with increasing momentum coefficient, and no significant change in the spectral distribution. This suggests that the jet sheet is not very effective in suppressing the Karman vortex under the above conditions.

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