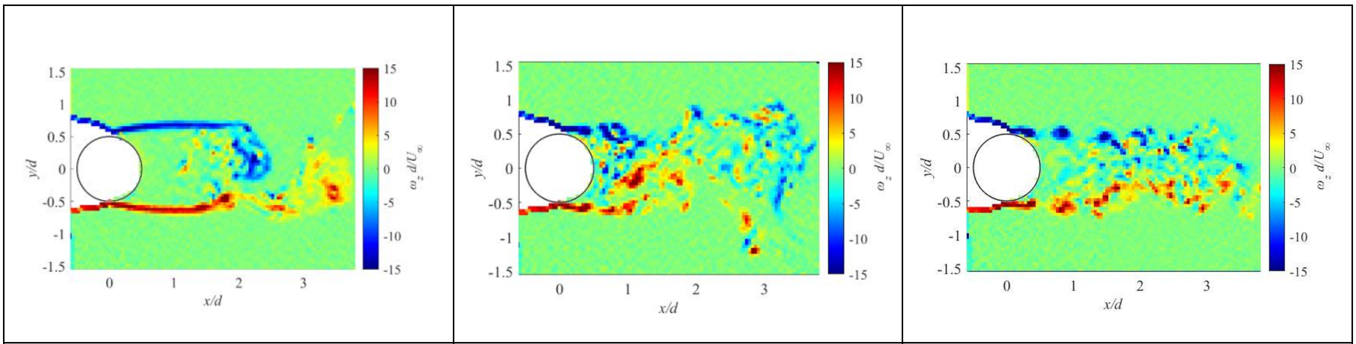
Wake behind circular cylinder excited by spanwise non-uniform disturbances

Takumi Kamiyama*, Mizuki Ino, Yudai Yokota, Jun Sakakibara

Department of Mechanical Engineering, Meiji University
Higashimita 1-1-1, Tamaku, Kawasaki, 214-8571, Japan

ABSTRACT

We studied a modification of wake behind a circular cylinder using a plasma actuator. The plasma actuators were arranged in the spanwise direction of the cylinder to give temporal periodic disturbances having Strouhal number St = 0.18-2.3 with a burst ratio BR = 20 and 40%. The Reynolds number was set in a rage of Re = 4200 to 8400. Two types of plasma actuator were prepared; one is a single strip of the actuator placed at each side of the cylinder to give a spanwise uniform disturbance, and another is an array of small piece of actuators placed at the same location to create a spanwise non-uniform disturbance with temporal phase difference, φ = 0 or π, between adjacent electrodes. A conventional two-component PIV and stereo PIV was used to measure the flow field. Figure 1 shows the instantaneous spanwise component of vorticity at Re = 4200 evaluated by two-component PIV. Under no disturbance condition, the laminar shear layer extends straight to around x / d = 1.5 and then forms a wake vortex, as shown in Fig.1(a). In the case of spanwise non-uniform forcing with St = 1.09 and φ =π, rapid roll up of the initial shear layer leads to arrangement of wake vortices closer to the cylinder., as shown in Fig.1(b). With higher Strouhal number case with St = 1.09 and φ = 0, shown in Fig.1(c), a series of fine scale vortices are generated behind both side of the cylinder without forming regular Karman vortices. The spanwise non-uniform forcing was effective to suppress the formation of large scale vortices just behind the cylinder. Figure 2 shows surface of constant vorticity magnitude and vortex lines under St =1.09 and φ = π case. These were computed from a phase-averaged three-components velocity field evaluated by stereo PIV. The value of the surface was selected to display the boundary layer formed on the cylinder, and the vortex lines are selected to visualize the vortex structure formed in the following shear layer. A bundle of vortex lines are shaped in a wavy pattern along spanwise direction with 180 degrees out of phase to the adjacent bundle upstream of downstream. This structure, so called 'chain-line fence structure' was already found in planar free shear layer [Nygaard, K.J. and Glezer, A., 1990, *Phys. Fluids* A, **2**, 461] and planar jet [Sakakibara, J., Anzai, T., 2001, *Phys. Fluids*, **13**, 1541], but it became evident to create it in the wake of circular cylinder in this study.



(a)PA off	(b)*St*=1.09, *φ*=π	(c)*St*=1.09, *φ*=0

Figure 1 Instantaneous vorticity distributions at *Re* = 4200

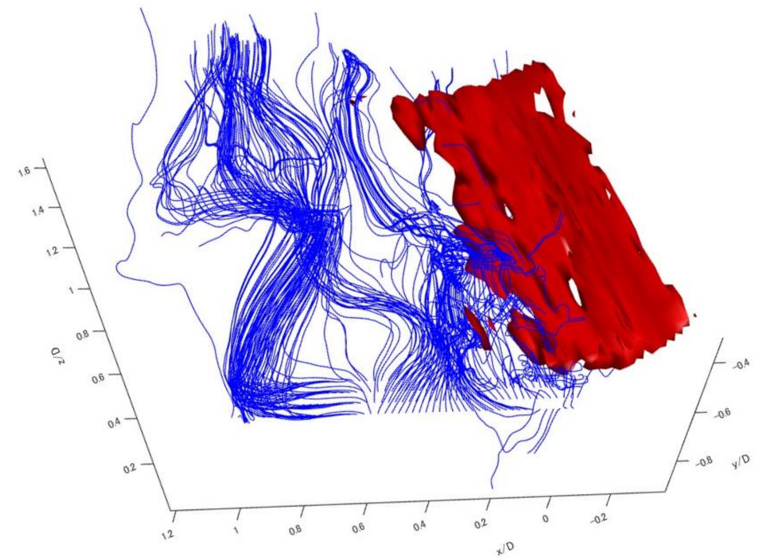


Figure 2 Surfaces of constant vorticity magnitude and vortex lines extracted from a phase averaged velocity field line under *St* =1.09 and *φ* = π case.