Analysis of vortex shedding mechanism through PIV measurement of flow past a rotating circular cylinder

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The vortex shedding mechanism of a rotating circular cylinder is investigated experimentally using Particle Image Velocimetry (PIV) method. Through this investigation, it is hoped that understanding of the mechanism of the vortex shedding of a rotating circular cylinder will lead to better understanding of the cylinder’s rotation effect on the flow structure around the cylinder.

Experimental method

The experiments were conducted for flow past a circular cylinder with an aspect ratio of 16 in a recirculating water channel at a Reynolds numbers of 110 and 206. The rotational to translational speed ratio \( \alpha \) varies from 0 to 3. The PIV measurement was carried out in a cross section plane of the cylinder at the cylinder’s mid span (of the immersed part of the cylinder in the water channel). A Litron laser system and a Dantec PIV2100 processor system were used to measure the flow field. Spherical glass particles 10 microns in diameter were chosen as seeding particles. A Kodak ES1.0 Digital CCD Camera located with line of view approximately perpendicular to the laser plane was used to capture the flow images. The vortex shedding process is analyzed by studying the time sequence of vorticity contours and streamline patterns in the surrounding field of the cylinder surface and in the wake of the cylinder.

Results

The vortex shedding was observed up to \( \alpha = 3 \) (up to \( \alpha = 2 \) at \( Re = 1000 \) in Chew et al. (1995)). In the range of \( 0 < \alpha < 3 \), the present result shows that the vortex formation mechanism seems to differ on the upper and lower side of the cylinder. At the lower side (rotation of the cylinder is in the same direction with free stream velocity), the positive anti-clockwise vortex is formed through the growth of a recirculating region, similar to the normal formation process in stationary cylinder, as described in Gerrard (1966). However, at the upper side (rotation of the cylinder is in the opposite direction with free stream velocity), the negative vortex is formed by interaction of shed positive vortex with the shear layer as it is being drawn much closer to the shear layer by the rotation of the cylinder.

Conclusion

The von Kármán vortex street is observed for both stationary and rotating cylinder at \( Re = 110 \) and 206. The vortex formation process on the upper side and lower side of the rotating cylinder shows some difference from that of the stationary cylinder.

References
