Abstract

A Computational Study of a Circular Cylinder at Low Reynolds Number for Open Loop Control of Von Karman Vortex Shedding

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A computational study of the flow past a circular cylinder at low Reynolds number is performed. At this Reynolds number Von Karman vortex shedding wake is observed. To attenuate this wake two actuators that inject fluid or remove fluid from the surface of the cylinder are used. The investigation is performed numerically by solving the Navier-Stokes equations in two-dimensions using OpenFOAM which is an open source code. The code is first validated without actuation on results from the literature for Von Karman vortex shedding at low Reynolds number and then used to study active (open loop) control of vortex shedding to reduce drag and control the vortex strength.

For physically accurate and for a numerically efficient solution, the time resolution, grid resolution, and domain independence are analysed to obtain the best compromise between physical accuracy and numerical computation. The numerical simulation is compared to experimental results in the literature and is found to closely match the experimental results of a Von Karman vortex street at low Reynolds number. To suppress the wake oscillations, two control actuators are implemented at the cylinder boundary at $\pm 110° \sim 130°$ from the leading stagnation point. Then with one actuator injecting fluid while the other is removing fluid by suction the effect of varying the actuator flow velocity is examined. It is found that generally the cylinder wake vortex shedding strength decreases gradually, as the velocity of the control flow is increased from 10% to 100% of the free stream velocity. Finally, to examine the effect of different types of control actuation on the vortex shedding the actuation was changed to: injection/suction, suction/injection, pure suction, and pure injection. All cases, but pure injection achieve almost complete suppression of vortex shedding in the wake at the Reynolds number 100 if the actuator flow velocity is on the order of the free stream velocity. In the case of pure injection the flow is destabilized and a stronger periodic wake is observed with the control flow turned on.

The flexibility of the open source code will allow us to implement a variety of time varying boundary conditions on the surface of the cylinder as different control strategies are explored. This will allow feedback control strategies that require smaller amounts of flow injection to be investigated.