ALE-FSI Computation of Two-Dimensional Flag-in-Wind Problem Fully-Resolving Trailing Edge Vortices of the Flag

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ABSTRACT

It is known that vortices shedding from the trailing edge of a sharp object become much smaller than the object itself as the Reynolds number, so the computation resolving fully the trailing edge vortex needs smaller scales both in time and in space than those defined by the object itself or its motion. So, numerical data for such Reynolds numbers and experiments that can be referred for exact comparison of computations and experiments are still limited especially for fluid-thin structure interactions like the flapping flag in the best of our knowledge. As a contribution to the state, we present a direct numerical simulation of a two-dimensional flag-in-wind problem that is fully resolving trailing edge vortices of the flexible object. If we define Reynolds number by length of the *flag*, it becomes about 40,000-100,000.

For validating the present computation, we introduce a filament-in-flowing soap film experiment of Zhang et al. [1], where a soap film is used for studying dynamics of immersed filaments as a model for one-dimensional flags in a two-dimensional wind. In the experiment, they visualized trailing edge vortices both for the flapping and the not-flapping cases. The vortices observed are much smaller than the scale of each flap and they form narrow procession nearly aligned with the wake. Furthermore, when the filament is swinging to the right, rotation of the vortices becomes clockwise-one, while to the left, it changes to anticlockwise-one. Huber [2] reviewed this vortex shedding compared with the cases for a rigid object and a swimming fish.

We are interested in whether the FSI phenomenon including the vortex shedding can be reproduced by computation exactly. We show the results in our presentation. The computation needs full resolution of thickness scale of the filament and the boundary layer, so we employed the interface-tracking ALE finite element method that keeps an interface-fitted mesh throughout the simulation, with an implicit time computation of a monolithic formulation of fluid and structures. Its main part is described in [3]. Lower Reynolds number cases, i.e. 300-1,000, for a similar set-up are shown in [4].

REFERENCES

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