Hydrodynamic loads simulation for 3D bluff bodies by using the vortex loops based modification of the vortex particle method

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ABSTRACT

For calculation of unsteady aerodynamic loads acting on aircraft which moves at low subsonic speed, vortex methods are highly efficient, as they require significantly less computational resources in comparison with grid-based methods. There are number of models of vortex elements known for flow simulation around 3D bodies: closed vortex framework, vortex filament, vorton, vortex dipole, vortex fragmenton, etc. Each of them has some advantages and disadvantages.

In number of modifications of vortex methods vorticity is concentrated in vortex framework segments and it is absent outside them in the flow. Some of these methods require number of empirical models to determine the location of the vortex sheet separation lines. In case of vortex methods with separate vortex particles (vortons) flow separation regions are being formed 'naturally' due to vorticity flux approach – vorticity generation on the whole surface and further self-organization of the vortons in the flow [1]. The main part of the vorticity is concentrated in proximity of vortons. However in the flow region, according to the Helmholtz theorems, there will be non-zero distributed 'additional' vorticity. Its intensity vanishes on infinity [2]. This additional vorticity may cause significant errors when computing aerodynamic loads acting the body. Recently, there was proposed an approach according to which the vorticity flux is being simulated by vortex filament loops generation on the body surface for 3D smoke dynamics simulation [3].

In the present paper the modification of vortex method is developed which is based on closed vortex loops usage for calculation of unsteady aerodynamic loads acting on bluff bodies.

It is shown that such approach has number of advantages for simulation of the evolution of vortex wakes behind bluff bodies. Each vortex loop can be considered as the separate vortex "superelement", which doesn't generate any additional vorticity. The loops generation algorithm allows to simulate the separation zone due to the self-organization of loops. The obtained results are in satisfactory agreement with known experimental data.

REFERENCES

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