Numerical solution of the Navier–Stokes equations in the problems of separated flows

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The present research centers upon the problems of separated flows around a circular cylinder in unbounded space, near a moving wall and flows around two cylinders. We study the mechanisms of vortex formation in a near wake and the processes of the further spatial development of vortex structures in a far wake. Our research is also devoted to the effect of external influence (the moving wall and the second cylinder) on these processes.

Two numerical methods are used for solving boundary value problems for the Navier–Stokes equations describing two–dimensional flows of a viscous fluid (gas): the finite difference method on structured grids and the stabilized finite element method on unstructured adaptive grids [1, 2]. The results are obtained for the computational domains extended downstream of up to 1000 radii of the cylinder at Reynolds numbers Re ≤ 500. Computations are carried out on Lomonosov supercomputer.

In [3] it is experimentally shown that after the Karman street decay the formation of a secondary vortex street, which has a larger scale is possible. The secondary vortex street occurs as a result of hydrodynamic instability [4] and is highly sensitive to the environment in which it has been experimentally studied [5]. Our numerical results allow us to distinguish the following characteristic zones of a vortex wake (Fig. 1): the region of vortex street formation (I); the Karman vortex street (II); the transition region (III); the secondary vortex street (IV); the region of chaotic vortex street (V). The dependence of the positions of the borders of these regions on external influences is studied.

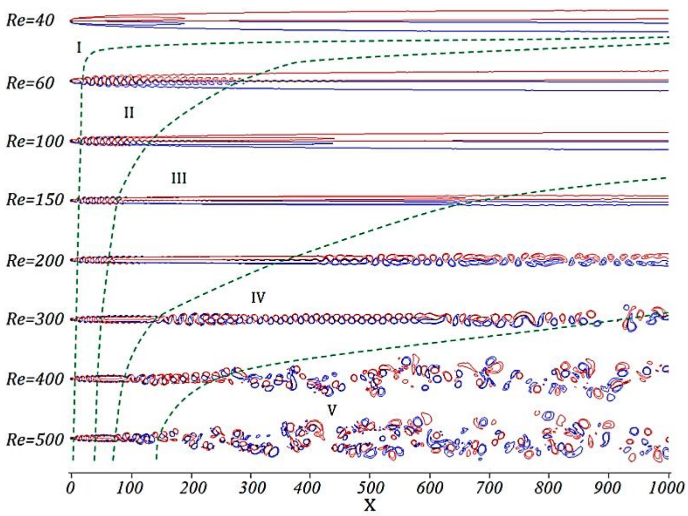

FIGURE 1. Vorticity contours and specific regions of circular cylinder wake at Re = 40 ÷ 500.

The connection of flow problem with the problem of hydrodynamic instability is built by using the symmetric and the antisymmetric components of a flow. By this approach we shown that the existence and main properties of self-oscillation regimes are specified by the evolution of their hydrodynamic instability and found that the development of different hydrodynamic instability modes correlates with the transient processes in the main flow.

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