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NUMERICAL MODELING OF SWIRLING TURBULENT WAKES

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The longitudinal component of excess momentum J and angular momentum M are the most important integral characteristics of the hydrodynamic wake past a body moving in unbounded fluid. The laws of turbulent motion in the wake essentially depend on these parameters. The nonswirling wake past a towed body is one of the best-studied cases. In such a wake, the excess momentum is equal to the hydrodynamic resistance of a body and the angular momentum is zero. If the propulsor does not impart any swirling to the stream than the angular momentum is zero. The momentumless wake of this kind has been studied experimentally and theoretically or numerically in many works. These studies reveal that the laws governing the development of the wake past the towed and self-propelled bodies are quite different.

The present study deals with the numerical simulation of the wake when both the momentum and the angular momentum take zero values. The flow pattern is calculated within the framework of the thin shear layer approximation for nonclosed system of the motion and continuity equations. The closed system of equations is written for two different formulations of the closure relations. In the first Model the normal components of the Reynolds stress tensor and the tangential stresses $< u'v' >$, $< v'w' >$ are determined from the corresponding differential transport equations. The turbulent shear stress $< u'w' >$ is derived from the algebraic approximation suggested by W. Rodi. In the second Model the differential equations are formulated only for the normal components of the Reynolds stresses. The shear stresses are evaluated from the algebraic relations of W. Rodi. Both of the above-mentioned mathematical models include the transport equation for the rate of dissipation.

The numerical solution of the problem is performed with the use of the finite-difference algorithm realized on moving grids. The algorithm is conservative with respect to the laws of conservation of the momentum and the angular momentum.

The experimentally measured distributions are used as the initial conditions. Both the models described agree well with the experimental data of Lavrentyev Institute of Hydrodynamics SB RAS. However, the second model shows better agreement. It is demonstrated that at the large distances downstream from the body the solution of the problem approaches the self-similar one. Simplified models of far turbulent wake behind self-propelled body have been constructed. The numerical simulation of passive scalar dynamics in turbulent wake was carried out. A numerical analysis of the evolution of swirling turbulent wake in a passively stratified fluid has been carried out. The case of the wake flow with a zero value of total excess momentum and a nonzero value of angular momentum was considered.

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