ADAPTIVE CHANGE OF THE SPATIAL RESOLUTION PARAMETER IN THE APPROACH TO THE DESCRIPTION OF TURBULENT FLOWS BASED ON PARTIALLY AVERAGED NAVIER-STOKES EQUATIONS

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Nowadays, the use of hybrid approaches to describe turbulent flows has become a standard practice in computational fluid dynamics. These approaches allow combining the resolution of a sufficient range of flow scales and acceptable computational cost. This is achieved by using different methods for describing turbulent flows (RANS/LES) in different spatial domains. Switching between the methods is usually controlled by parameters based on the ratio of the integral turbulence length and the grid scale. There are also other approaches, such as PITM (Partially Integrated Transport Model) [1], in which the separation of scales is carried out in the space of wave vectors, and PANS (Partially-Averaged Navier Stokes) [2], in which the controlling parameter is the ratio of the unresolved turbulent kinetic energy and the total turbulent kinetic energy corresponding to Reynolds averaging. The constant value of the ratio $f_k = k_u / k$ in the PANS approach allows achieving an intermediate spatial resolution of the flow between RANS and LES. However, only a dynamically changing value of f_k can provide the desired accuracy of modeling. This, in turn, leads to the non-commutativity of the averaging operator with spatial and time derivatives and the need to take into account additional terms in the basic system of equations. In [3, 4], a model based on the principle of conservation of total energy was proposed to close the final system of equations.

In this paper, using the example of the problem of decay of homogeneous isotropic turbulence, the use of the approach based on partially averaged Navier-Stokes equations (PANS) with various options for changing the parameter f_k, including a constant value, a dynamic value in accordance with a given law, and an adaptive value based on instantaneous flow characteristics is demonstrated.

References

1. **Schiestel, R.** Towards a new partially integrated transport model for coarse grid and unsteady turbulent flow simulations [Text] / R. Schiestel, A. Dejoan // Theoretical and Computational Fluid Dynamics. – 2005. – Vol. 18, No. 6. – P. 443–468.
2. **Girimaji, S. S.** Partially-Averaged Navier-Stokes Model for Turbulence: A Reynolds-Averaged Navier-Stokes to Direct Numerical Simulation Bridging Method [Text] // Journal of Applied Mechanics. – 2006. – Vol. 73, No. 3. – P. 413–421.
3. **Wallin, S.** Commutation error mitigation in variable-resolution PANS closure: Proof of concept in decaying isotropic turbulence [Text] / S. Wallin, S. Girimaji // 6th AIAA Theoretical Fluid Mechanics Conference. American Institute of Aeronautics and Astronautics, – 2011.
4. **Girimaji, S. S.** Closure modeling in bridging regions of variable resolution (VR) turbulence computations [Text] / S. S. Girimaji, S. Wallin // Journal of Turbulence. – 2013. – Vol. 14, No. 1. – P. 72–98.