0.1. *Бернар А.* Machine learning aided RANS models for turbulent flows

Predictions of turbulent flows at high Reynolds numbers are of key interest in various applications of aerospace, energy, environment and other fields. However, computational fluid dynamics models either require too huge computing resources, such as eddy-resolving methods of direct numerical simulation (DNS) and large eddy simulation (LES), or lead to considerable errors and uncertainties, such as Reynolds-averaged Navier — Stokes (RANS) equation models. Despite the recent advancements in computational power, RANS models are still used widely to solve practical problems. The goal of the current work is to improve the accuracy of the latter models, through the use of machine learning (ML) algorithms, while keeping its computational time relatively low.

To perform this task, high-fidelity data from DNS and LES for different canonical flows is coupled with the relating low-fidelity data from RANS simulations [1]. Two ML methods are considered: tensor basis random forest [2] and tensor basis neural network [3]. They both rely on the assumption that the Reynolds stress anisotropy (RSA) tensor can be expressed as the linear combination of a basis of ten tensors [4] extracted from the RANS simulation data. To obtain new results, the RSA tensor is propagated into a RANS solver modified properly. The baseline RANS solver includes the linear eddy viscosity model (LEVM) approximation to compute RSA, while the modified solver uses the ML predicted RSA instead. All RANS simulation data are obtained using the OpenFOAM software, with the baseline (simpleFoam) and modified solvers.

This work explores the ability of the ML models to predict accurately the RSA tensor in two-dimensional steady state computations of canonical turbulent flows in channels versus that of LEVM, as well as the impacts on the velocity behavior after propagation of the RSA fields obtained using ML.

Научный руководитель — д.ф.-м.н. Яковенко С. Н.

Список литературы

[1] McConkey R., Yee E., Lien F.-S. A curated dataset for data-driven turbulence modelling // Sci. Data. 2021. Vol. 8. 255.
[2] Kaandorp M. L. A. Dwight R. P. Data-driven modelling of the Reynolds stress tensor using random forests with invariance // Comput. Fluids. 2020. Vol. 202. 104497.
[3] Ling J., Kurzawski A., Templeton J. Reynolds averaged turbulence modelling using deep neural networks with embedded invariance // J. Fluid Mech. 2016. Vol. 807. P. 155–166.
[4] Pope S. B. A more general effective-viscosity hypothesis // J. Fluid Mech. 1975. Vol. 72. N. 2. P. 331–340.