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DNS SIMULATIONS OF COUETTE FLOW AT LOW REYNOLDS NUMBERS USING OPENFOAM FOR OBTAINING EFFECTIVE VISCOSITIES FOR A NEW TURBULENT MODEL

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Abstract.
This paper presents an initial stage of a new turbulent model based on effective viscosities. The model proposes solving a ”global” problem using a relatively thick mesh with a pseudofluid with precalculated effective viscosities. These viscosities are proposed to only depend on the global cell gradients of velocity and pressure, which are the input variables to the database. The global solver, whose details fall outside the scope of this work, calculates the velocity and pressure gradients in each cell of the global mesh, and with these data accesses the base to obtain the corresponding effective viscosities to be used in the next global time step. The database is assembled using DNS simulations of a set of ”local” problems in cubic domains with structured cubical meshes, using jump boundary conditions to impose the desired velocity and pressure gradients. Each case is simulated until a turbulent steady state is achieved. The results are postprocessed to obtain turbulent shear stresses and averaged velocity profiles in a subdomain of the local problem, called the Representative Volume Element (RVE). With these values, an effective viscosity is calculated and stored in the database, associated with the gradients imposed in the case. A distinction is made between wall RVEs when one of its faces is in contact with a solid wall, and internal RVEs otherwise. A database is built for each one of these two types. The present work focuses on the resolution of local problems to build the database of wall RVEs. The work includes DNS simulations of turbulence in cubic domains in a set of incompressible Couette flow problems between parallel plates with imposed pressure gradient. Cases with different relative speeds between the plates and different pressure gradients are analyzed. The pressure gradient is imposed as a jump condition between the input and output faces of the cube. As for the velocity, periodic conditions are imposed on the lateral and inlet and outlet boundaries. Only marginally turbulent cases, with very low Reynolds number, close to the transition zone, are considered. The purpose is to perform conceptual tests of the proposed new model at reasonable computational costs. We present some of the simulated local cases, and the resulting database for the range of Reynolds numbers considered. In addition, simple examples of global problems solved with the aforementioned turbulent model are presented.

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