information/communication technologies; deepen scientific and methodical maintenance of small business.

Ukraine has significant research and technology potential. Therefore we can't allow the economic situation and insufficient poor legislation to stop its further development.

TURBULENCE CLOSURE MODELS

A. Nenja, postgraduate student.

CFX-Taskflow is an integrated software system capable of solving complex multidimensional fluid problems. The fluid flow solver provides solutions for incompressible or compressible, steady-state or transient, laminar or turbulent single-phase fluid flow in complex geometries.

A large number of flows that are modeled are turbulent, and therefore turbulence models are an important component of a CFD code.

The mean flow equation section introduces the Reynolds stresses, and the subsequent closure problem, which results when the instantaneous Navier-Stokes equations are time averaged. To avoid the resolution of all turbulence time scales, these equations are statistically averaged, resulting in new unknown turbulence quantities in the averaged equations. This leads to the so-called closure problem. New transport equations can be derived for the unknown turbulence quantities, but these equations contain again new unknown turbulence quantities. Model assumptions for these unknown turbulence quantities have to be found based on known quantities. . The level where the equation system is finally closed and the number of additional equations for turbulence quantities define the type of the turbulence model and can be used to classify existing turbulence models.

Two-equation turbulence models are very widely used, as they offer a good compromise between numerical effort and computational accuracy. The k-ε and k-ω two-equation models use the gradient diffusion hypothesis to relate the Reynolds stresses to the mean velocity gradients and the turbulent viscosity.

In two-equation models the turbulence velocity scale is computed from the turbulent kinetic energy, which is provided from the solution of its transport equation. The turbulent length scale is estimated from, usually the turbulent kinetic energy and its dissipation rate. The dissipation rate of the turbulent kinetic energy is provided from the solution of its transport equation.

A major improvement in terms of flow separation predictions has been achieved by the k — ω based SST model. It accounts for the transport of the turbulent shear stress and gives highly accurate predictions of the onset and the amount of flow separation under adverse pressure gradients.

For strongly anisotropic flows, full second moment closure (SMC) models have been developed. These models are based on transport equations for all components of the Reynolds stress tensor and the dissipation rate. The SMC models naturally include effects of streamline curvature, sudden changes in the strain rate, secondary flows or buoyancy compared to turbulence models using the eddy-viscosity approximation. The biggest drawback of Reynolds Stress models is that the increased number of additional transport equations leads to a reduced numerical stability and requires increased computational effort.

To overcome these problems, but still retain a high universality Rodi proposed the idea of algebraic stress closure, which provides algebraic equations without solving differential equations for the Reynolds stresses. This led to a new class of two-equation models with coefficients that depend on rotational and irrotational strains, the Algebraic Stress models (ASM). The predictions of these models often come close to those of an Reynolds Stress model at a significantly lower level of complexity.