NEW APPROACH ON MODELING THE GRADIENT OF REYNOLDS SHEAR STRESS IN FULLY-DEVELOPED TURBULENT CHANNEL FLOW

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Abstract

The current work is aimed to present the new approach on modeling the gradients of the Reynolds stresses that does not rely on the eddy viscosity concept. The gradients of the Reynolds stresses are modeled in terms of the gradients of the product of the root-mean-square of velocity fluctuations times a constant. The Direct Numerical Solution (DNS) data of fully-developed turbulent channel flow of Kim, Moin and Moser (1987) at two Reynolds numbers ($Re_\tau \equiv u_\tau h / \nu$ = 180 and 395 where $u_\tau \equiv \sqrt{\tau_w / \rho}$ is the friction velocity and h is the channel half-height) are used to evaluate the proposed model in comparison with the eddy viscosity models. The standard high-Reynolds-number $k-\varepsilon$ model (1974), low-Reynolds-number $k-\varepsilon$ model of Launder and Sharma (1974), and $k-\varepsilon-\overline{v'^2}$ model of Durbin (1991) are chosen to represent the turbulence models that are based on the eddy viscosity concept. It is found that the proposed model is able to predict the velocity profile in the viscous sublayer and the buffer layer accurately. The predicted velocity profile in the logarithmic layer from the proposed model is closer to the DNS data than the velocity profile from the low-Reynolds-number $k-\varepsilon$ model of Launder and Sharma (1974) and the trend is close to that from the $k-\varepsilon-\overline{v'^2}$ model of Durbin (1991). Furthermore, only two extra transport equations of the root-mean-square of velocity fluctuations are solved in the proposed model compared to three extra equations in the $k-\varepsilon-\overline{v'^2}$ model of Durbin.

Keywords: Turbulence Modeling, Reynolds Stresses, Eddy Viscosity, Root-Mean-Square of Turbulent Fluctuations, Fully-Developed Turbulent Channel Flow

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