CFDWARP — Wilcox 2008 $k\omega$ Turbulence Model

THE FLUID FLOW EQUATIONS solved by CFDWARP are the so-called Reynolds-averaged Navier-Stokes (a.k.a. RANS) equations closed by the 2008 Wilcox $k\omega$ [1] turbulence model. The RANS equations correspond to a time average of the turbulence eddies occurring within the fluid flow. Such is generally necessary when solving high Reynolds number flows using a digital computer because too many nodes would be required to resolve properly the turbulence eddies. Because the time-averaging procedure introduces errors, the RANS methods are prone to yield erroneous results for certain types of flowfields.

Two such flowfields that are notorious for being particularly difficult to predict are (i) the separation of the boundary layer caused by a shockwave and (ii) free shear layers within round jets. The latest version of the widely used $k\omega$ model [2] addresses these issues. Indeed, the 2008 version [1] of the $k\omega$ model exhibits much improved accuracy in solving shockwave-boundary-layer problems and free shear layer growth in round jets. In the case of the latter, the latest $k\omega$ model yields a shear layer spreading rate within 10% of the experimental data, while the original overpredicts the shear layer spreading rate by more than 3 times.

Further, like previous versions, the 2008 $k\omega$ model can be integrated throughout the laminar sublayer of the turbulent boundary layer. Because of this, it can predict well boundary layer separation even under adverse pressure gradients, such as those that are likely to occur in plasma flow control.

As well, Because the MHD interaction can hamper the growth of the turbulent eddies, a correction to the two-equation model to account for the MHD effects on turbulence [3] is also implemented within the CFDWARP code.

References

[1] DC Wilcox, “Formulation of the $k\omega$ Model Revisited,” *AIAA Journal*, Vol. 46, No. 11, 2008, pp. 2823.

[2] DC Wilcox, “Reassessment of the Scale Determining Equation for Advanced Turbulence Models,” *AIAA Journal*, Vol. 26, No. 11, 1988, pp. 1299–1310.

[3] S Kenjeres, K Hanjalic, “On the Implementation of Effects of Lorentz Force in Turbulence Closure Model,” *International Journal of Heat and Fluid Flow*, Vol. 21, 2000, pp. 329–337.