Physically-consistent wall boundary conditions for the k-ω turbulence model

A model solving Reynolds-averaged Navier–Stokes equations, coupled with k-ω turbulence closure, is used to simulate steady channel flow on both hydraulically smooth and rough beds. Novel experimental data are used as model validation, with k measured directly from all three components of the fluctuating velocity signal. Both conventional k = 0 and dk/dy = 0 wall boundary conditions are considered. Results indicate that either condition can provide accurate solutions, for the bulk of the flow, over both smooth and rough beds. It is argued that the zero-gradient condition is more consistent with the near wall physics, however, as it allows direct integration through a viscous sublayer near smooth walls, while avoiding a viscous sublayer near rough walls. This is in contrast to the conventional k = 0 wall boundary condition, which forces resolution of a viscous sublayer in all circumstances. Subsequent testing demonstrates that the zero-gradient condition allows the near-bed grid spacing near rough walls to be based on the roughness length, rather than the conventional viscous length scale, hence offering significant computational advantages.