Improving the Numerical Robustness of Buoyancy Modified *k-ω SST* Turbulence Model

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ABSTRACT

In most previous computational fluid dynamics (CFD) studies involving free surfaces progressive wave with RANS model, they always suffered from over-predicted turbulence near the interface especially for the short wave with high steepness. This over-prediction would lead to severe wave damping and make the results invalid. To overcome this problem, many researchers has modified the RANS model to improve the free surface simulation. The over-prediction is suppressed by: 1) adding a buoyancy term in the turbulent kinetic energy (TKE) equation and 2) redefining the eddy-viscosity to stabilize the model in nearly potential flow region. The new stabilized turbulence model prevents from the exponential growth of the eddy-viscosity and subsequent wave decay exhibited by original model. In this study, the modified models mentioned above are implemented in OpenFOAM. But our practice on modified k-ω SST model encountered server numerical instability. The numerical instability is caused by the sudden increase of turbulent viscosity. Careful inspection on the results show that this erroneous spikes in the eddy-viscosity is related to the dissipation rate, ω, going to zero in some grid cell near the free surface. To prevent this from happening, a new limiter is simply imposed on the buoyancy term in the TKE equation. This new limiter is validated by conducting 2D wave simulations. The numerical results show good agreement with the experimental measurements for the surface elevations, undertow profiles of the horizontal velocity and turbulent kinetic energy profiles. Meanwhile, the numerical stability is also guaranteed

Key words: Numerical instability, Wave decay, Buoyancy modification, Over-predicted turbulence, OpenFOAM