XI International Conference on Computational Methods in Marine Engineering

Verification and validation of frictional resistance of flat plates with and without roughness

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ABSTRACT

In this study, the frictional resistance coefficients of a flat plate with varying surface roughness levels were investigated across 11 Reynolds numbers, spanning from $\log_{10}(Re) = 6.25$ to $\log_{10}(Re) = 7.54$. The computations were carried out for both hydrodynamically smooth surfaces and rough surfaces, represented by six sand-grain roughness heights ($k_s = 10, 20, 30, 50, 100, 300$). Two turbulence models, $k-\omega$ SST and EASM, were employed to simulate the flow conditions. Following the procedure of Eça and Hoekstra (2008), a grid dependence study was performed for each Reynolds number and roughness level, e.g. see Figure 1.

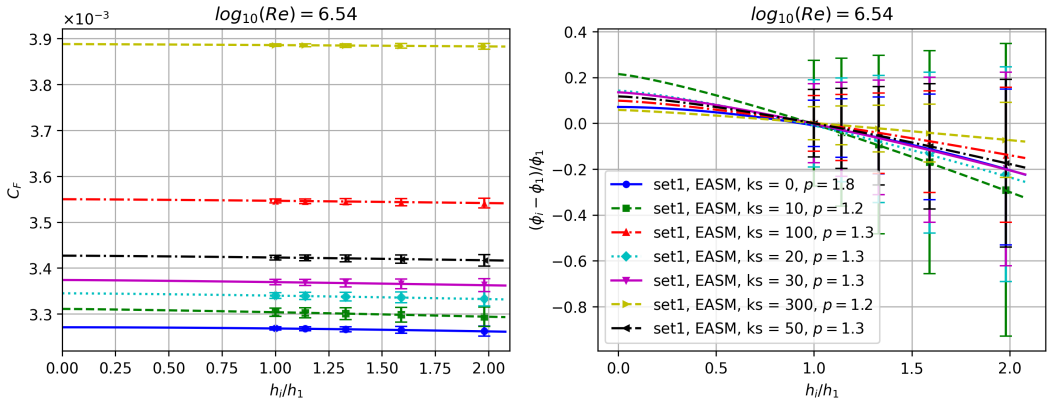

Figure 1: Grid dependence study with varying k_s values at $\log_{10}(Re) = 6.54$

The experimental study of Leer-Andersen (2018) on flat plates with varying average surface roughness (AHR) was reanalysed for obtaining the measurement uncertainties, facilitating a Verification and Validation (V&V) analysis and the derivation of correlation factors AHR$/k_s$ for each Reynolds number and turbulence model.

For all simulations, the no-slip condition was directly applied at walls without the use of wall functions. Special attention was given to the influence of y^+ values on the accuracy of the frictional resistance coefficients. The transition from laminar to turbulent flow, particularly at lower Reynolds numbers, was carefully examined.

This study extends the understanding of frictional resistance in the presence of surface roughness and provides a comprehensive assessment of numerical and experimental agreement through detailed V&V analysis.

References

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