Thin-Ship Theory of Wave Resistance on Finite-Volume Grids

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The flow around a surface ship is complex due to the high Reynolds number body-boundary layer which separates near the stern of the vessel, and the small amplitude-to-length ratio free-surface waves that extend many ship-lengths from the body. Conventional CFD techniques are well suited to solve this problem, and perhaps the greatest advantage they have over inviscid-fluid formulations is the capability to solve for the flow in the body-boundary layer and viscous wake. Unfortunately, the execution and subsequent results of these methods have had limited impact on the marine community due to the substantial computational expense in computing the solution in the entire fluid region of interest.

There is a powerful theory for computing the wave resistance that was published by Michell in 1898. A Green function is used to satisfy linearized free-surface and body boundary conditions, the strength of which is proportional to the longitudinal slope of the body. From the 1970's until today, the method has been used successfully by several research groups throughout the world. Programs based on the landmark theory have negligible computational expense. Also, the potential function satisfies the radiation condition exactly at infinity, which means the wake far from the body is very accurately represented.

It is of interest to be able to perform both a finite-volume and boundary element computation of the flow about a body translating steadily through calm water. The boundary-element solution will certainly arrive sooner, and it will be able to compute the wave elevation everywhere. The CFD computation will provide the total resistance, assumed more accurate, but also the comparison of the two solutions will permit us to learn about the "form factor", and the underlying assumptions in Froude's Hypothesis. In other words, we may be able to learn more about extrapolation of physical model test results.

We are currently working on solving Michell's integral on an arbitrary polygonal description of the vessel surface. The new solver, MichellFoam, utilizes the OpenFOAM libraries and case structure. In our presentation, we will discuss how we implemented the solution strategy of solving Michell's integral within OpenFOAM. We will show results for the computation of total, wave and residual resistances, done by MichellFoam and rasInterFoam.