HYDROFOIL SHAPE OPTIMIZATION BY GRADIENT METHODS

by

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ABSTRACT

A study was carried out to develop and test techniques for the computational optimization of hydrofoil sections and lifting surfaces advancing under a free surface. A mathematical model was developed based on the extension of a two-dimensional potential flow solution to account for three dimensional effects. Prandtl's lifting line theory was used to account for induced drag and downwash at the leading edge of the foil. Strip theory was used to extend the two-dimensional wave drag solutions to three dimensions for high aspect ratio foils. A semi-empirical correction was added to account for viscous drag.

The drag-to-lift ratio of foil sections and lifting surfaces were optimized using first order gradient techniques. Optimization studies involving submerged foil sections suggest that trading buoyancy for a reduction in wave drag will lead to optimal geometries. Difficulties encountered resulting from the adoption of a potential flow model were identified and discussed. The lifting surface optimization was carried out using the coefficients of Glauert's circulation series as design variables. At high speeds it was shown that non-elliptical loading can produce reductions in the drag-to-lift ratio of a lifting surface. Induced drag dominated the low-speed optimization, and elliptical loading was shown to be optimal at the low end of expected operating speeds of a hydrofoil vessel.

An adjoint formulation for the problem of optimizing the shape of a lifting section under a free surface was derived for use in future research.

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