3. EXTENDED ABSTRACTS AND DISCUSSIONS

APPLICATIONS OF NEUMANN-KELVIN THEORY

by

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Abstract

The investigation of steady ship motion in calm water is a classic problem in ship hydrodynamics, where ship waves and wave resistance are subjects of unquestionable importance. Despite considerable efforts in the past a satisfactory solution of the steady ship motion problem has not been achieved thusfar. The application of three-dimensional potential flow theory results in an essentially nonlinear problem formulation due to the unknown position of the disturbed free surface. In the linear Neumann-Kelvin theory the nonlinear free surface effects are neglected, but the three-dimensional features of the fluid flow and the hull geometry are otherwise fully retained. This approach is inconsistent from a formal mathematical point of view, but in practice it may be argued that ships are somewhat slender and operate at fairly low speeds and therefore generate small disturbances at the free surface.

Recently the authors have made an extensive investigation of the theoretical development and practical application of the Neumann-Kelvin theory [1-4]. Following a brief discussion of the theoretical development, this talk focuses the attention on the practical applications of the Neumann-Kelvin theory. Solutions to the linearised disturbance potential of the steady perturbed ship flow are obtained by means of a source distribution method involving the distribution of Kelvin wave sources over the ship's wetted hull surface and water line contour. The exact source stength is the solution to a Fredholm integral equation of the second kind [1,2,4]. An explicit source strength approximation, valid for sufficiently slender ship forms operating at low speeds, is given by the perturbed normal hull velocity [5]. The Kelvin wave source potential (i.e. the wave-resistance Green's function) has been analysed in great detail [4] and particular emphasis was placed on computational aspects. The Kelvin wave source potential can be decomposed into two components: (i) a nonoscillatory nearfield disturbance, symmetric upstream and downstream from the moving source, and (ii) a Kelvin wavelike disturbance trailing downstream from the source (and zero upstream). A fast algorithm for the nearfield disturbance has been proposed by Newman [6] who derived four complementary trivariate Chebyshev expansions. Bessho [7] has derived two complementary Neumann series expansions for the wavelike disturbance. These were used to derive a fast algorithm for the evaluation of this component [2].

The developed theory has been applied to a variety of ships, including a submerged prolate spheroid, Wigley's parabolic hull, the Series 60 C_b = 0.6 hull form, a full-bodied tanker, a fast destroyer with transom stern and a cruiser hull form. A selection of results is presented and discussed. Experimental and theoretical data are compared over a wide range of ship speeds and flow parameters, such as the wave resistance, ship-generated waves and pressures, lift force distributions and sinkage and trim.

References

[1] Baar, J.J.M. and Price, W.G., 1986, 'Developments in the calculation of the wavemaking resistance of ships'. To appear.

[2] Baar, J.J.M. and Price, W.G., 1986, 'Evaluation of the wavelike disturbance in the Kelvin wave source potential'. Submitted to J. Ship Res.

[3] Andrew, R.N., Baar, J.J.M. and Price, W.G., 1986, 'Prediction of ship wavemaking resistance and other steady flow parameters using Neumann-Kelvin theory'. Submitted to Roy. Inst. Nav. Arch.

[4] Baar, J.J.M., 1986, 'A three-dimensional linear analysis of steady ship motion in deep water'. Brunel Univ., Ph.D. Thesis.

[5] Noblesse, F., 1983, 'A slender-ship theory of wave resistance'. J. Ship Res., vol. 27, pp. 13-33.

[6] Newman, J.N., 1986, 'Evaluation of the wave-resistance Green function. Part 1: The double integral'. Submitted to J. Ship Res.

[7] Bessho, M., 1964, 'The fundamental function in the theory of the wavemaking resistance of ships'. Mem. Def. Acad. Japan, vol. 4, pp. 99-119.

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