Speed at Sea - Application to Ship Design

OPTIONS Design Exploration System

Computational Engineering & Design Centre

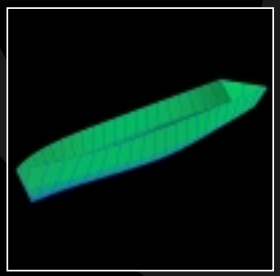
CEDC

The OPTIONS Design Exploration System has been applied to the design of low resistance ship hull forms. The designs are based on typical naval frigates and were produced using gradient descent optimization methods and a statistically based hull-form resistance code.

UK RN Type 22 Batch 2 Frigate at Speed

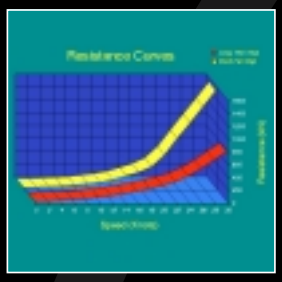
Naval frigates are required to operate at high speeds while remaining efficient at all times. Designers are therefore very concerned with the hull-form resistance of competing designs.

Simplified Hull-form Model



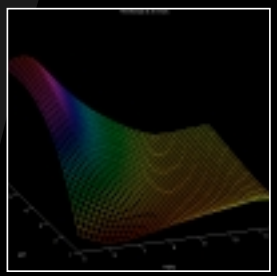
A simplified representation of each candidate hull-form must be produced for analysis using the resistance model. The analysis is based on a statistical interpretation of a large data-base of results from previous tests on model ships.

Variation of Resistance with Speed



Hull-form resistance rises rapidly with speed and it is clear that at high speeds efficient shapes must be chosen to limit the engine power needed in a design.

Variation of Resistance with Shape

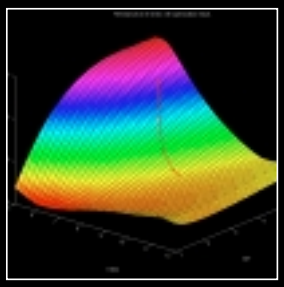


The hull-form of a ship is a highly complex shape but its principal dimensions may be varied by distorting the basic form. This can be achieved by varying the beam to draught ratio (B/T) and length to displacement ratio (Mcirc). Changes in these quantities have a profound affect on the resistance of a ship at a given speed.

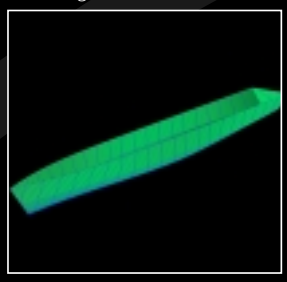
Ship Design System

Ship concept design must, however, consider many more aspects than just hull-form resistance. In the work presented here, account is taken of the required internal space for the crew and stores, fuel capacity, roll stability, strength, etc. All these aspects can have knock on effects on resistance, given that the designer must produce a concept capable of deploying the required payload and crew with specified fuel range and stores endurance. This leads to each resistance evaluation being underpinned by an extended sequence of related computations.

Optimization of Hull-form



Application of a gradient descent optimizer from within the OPTIONS package allows the hull-form to be rapidly modified to achieve minimum resistance at 30 knots. Here, an active constraint is placed on the design by the need for adequate hull girder strength, which effectively limits the length to hull depth ratio of the design.



Optimized Design
The final, optimized design is considerably longer and thinner than the base ship with a resistance that has nearly halved compared to the starting point, even though the overall displacement has increased. Rather shorter and fatter designs result if the maximum design speed is reduced, since at such speeds wavemaking resistance is considerably lessened and the need for such a fine form diminishes.

Full references for papers describing this work and a number of related subjects may be found on the home page of Prof. A.J. Keane

(http://www.soton.ac.uk/~ajk/welcome.html).

This article may be found at http://www.soton.ac.uk/~ajk/ship/ship.html

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