CHSV at 40 knots in head waves.

Cooperation helps wing the way to success

In a fascinating project MARIN has been asked to determine the resistance, seakeeping and manoeuvring characteristics, of blended wing body technology which involved one of the most complex models MARIN has ever tested.

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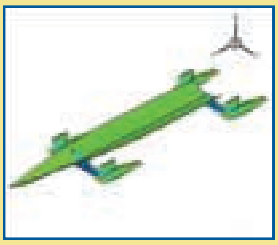
Given the current trend in mission requirements for high speed vessels, there is a growing demand to reduce hydrodynamic resistance and expand maximum speeds in a seaway on large displacement vessels. To this end, Navatek Ltd., a leader in design and construction of innovative, advanced ship hull systems, patented a design to enhance the lift of a vessel. The design incorporates blended wing body systems forward and aft. Each blended wing body system consists of two lifting bodies connected by a hydrofoil. While the hydrofoil provides lift, the large underwater lifting bodies provide motion damping to increase seakeeping capabilities.



Panship pressure coefficients at 40 knots.

In order to prove the hydrodynamic advantages of the blended wing body system, the United States Office of Naval Research (ONR) sponsored computational studies and hydrodynamic model testing on a vessel containing the Navatek patented design. The research group for this project included Northrop Grumman Ship Systems (NGSS), Navatek Ltd., and MARIN, and the project goal was to quantitatively determine the resistance, seakeeping and manoeuvring characteristics of a monohull outfitted with the blended wing body technology (identified as CHSV or Composite High Speed Vessel) to an equivalent conventional monohull (identified as HSV or High Speed Vessel).

Optimisation through CFD

Prior to model fabrication both hulls were optimised using CFD tools. Using MARIN's potential flow code RAPID and viscous flow code PARNASSOS, the HSV hull form was optimised for wave making characteristics and chine alignment. The optimisation of the CHSV proceeded using the computational tools and expertise of NAVATEK. For both the vessels 3D non linear time domain seakeeping calculations were performed using MARIN's PANSHIP code. This code, which is specifically developed for high speed vessels, assisted in the optimisation of the ride control systems and gave an early indication of the seakeeping performance of both vessels.

Complex models a challenge

Models of the CHSV and HSV manufactured to a scale of 1:18 were used for seakeeping, manoeuvring and powering tests. The HSV model was a relatively simple model with a double chine hull form propelled by two water jets and equipped with active trim flaps and fin stabilisers. The more complex CHSV model consisted of a centre hull form with outriggers (ama's) on the side. It was equipped with three water jets and two blended wing body systems, one fore and one aft. The cross foils of the blended wing body systems were equipped with two flaps, port and starboard, for motion control. In addition to these control surfaces, the aft struts of the blended wing body system also had a vertical flap for directional control. In total the model was equipped with six servo actuated flaps. During the free running model tests all the flaps and water jets were active. With the active flaps and jets and the need to measure midship bending moment and loads in each blended wing body, the CHSV model was one of the most complex models ever tested at MARIN.

Model tests

For both vessels free sailing seakeeping and manoeuvring, resistance, powering and captive manoeuvring tests were performed. The purpose of the model tests was threefold: to obtain data to quantify the hydrodynamic performance of both vessels in calm water and motions in a seaway, to obtain engineering data to quantify such things as loads in the struts and midship bending moments, and to use the obtained model test results to fine tune the designs.

The test program started with seakeeping and manoeuvring tests where issues which could not be calculated were investigated in the tank. Waterjet inlet ventilation was one such issue. Using under water cameras, it was possible to detect if and how air bubbles were entering the water jets. Using these observations the forward strut/ama and spray rail configurations were optimised to give the lowest possible disturbances (air bubbles) in the water. In addition, the effect of spray on the vessel performance was quantified, leading to design changes that proved to significantly improve the spray associated with vessel operations.

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CHSV model (above) and HSV model (below).

Cooperation a key to success

A comparison was made between the two optimised concepts using the model test data. The results of the seakeeping tests show that CHSV (lifting body concept vessel) performed equal to or better than the monohull (HSV) design. In calm water a small increase in resistance was found over the HSV design. The results suggest that an improvement can be achieved by further optimising the position of the cross foil with respect to the hull, as interference phenomena were observed between the hull and the two blended wing body systems. The manoeuvring characteristics between the two vessels are quite different. This is due to the large vertical struts on the CHSV which make it more course stable than the HSV, but also increase the turning circles over HSV.

The cooperation between all parties involved resulted in a very successful project. The use of CFD in the initial phase together with model tests in the later phase helped reduce development time and costs while producing valuable engineering information for the final design. Once again, this approach has proven indispensable in the development of new concept designs.