Fuel saving device also enhances vessel motions

Trials on a Royal Netherlands Navy Holland-class offshore patrol vessel suggest that the Hull Vane developed by naval architects Van Oossanen and sister company Hull Vane BV has much to offer the naval market

The Hull Vane in a two-strut configuration

The Hull Vane is an appendage that looks a little like an underwater spoiler, of the type one might find on a fast car. The patented fuel saving device consists of a submerged hydrofoil-type appendage, fixed at or below the stern of a ship. Unlike hydrofoils, the goal is not to lift the vessel out of the water but to generate forward-oriented lifting force and reduce a ship's stern wave. It reduces the fuel consumption of ships through four different effects: it produces forward thrust out of the upward flow under the aft ship; reduces wave-making or pressure resistance; generates vertical lift to reduce the running trim of a ship; and reduces ship motions in waves such as pitching, heaving, rolling and yawing (and therefore the added resistance caused by these motions).

The Hull Vane was invented by Dr Ir Peter van Oossanen and is patented in all major shipbuilding countries. It has been successfully applied on a 30m catamaran (reducing fuel consumption by up to 20%), a 42m motor yacht (reducing fuel consumption by 20%) and a 55m Fast Supply Intervention Vessel (where it reduced fuel consumption by 10-15%).

More recently, Van Oossanen carried out an extensive study on the application of the Hull Vane to a 108m offshore patrol vessel (OPV) operated by the Royal Netherlands Navy, and found that the fuel savings that accrued averaged 12.5% over the vessel's operating profile. Interestingly, fitting the Hull Vane also enhanced some aspects of the OPV's seakeeping. The vessel in question and its sister vessels were built for the Royal Netherlands Navy by Damen Schelde Naval Shipbuilding between 2008 and 2011. The goal of the design of the ships was to create a cost-efficient vessel for coastguard, anti-piracy and search and rescue missions. These tasks used to be carried out by frigates, which are 'over-qualified' for the job, and costly in terms of fuel consumption, crew and armament. The top speed of the Holland-class vessels was set at a moderate 21.5knots (service conditions), with the understanding that fast interventions could be carried out by its fast raiding interception craft – which have a top speed of 45knots – and its NH90 helicopter. The Holland-class OPVs have two controllable-pitch propellers, driven directly by two diesel engines. For low-speed patrol activity, two electric motors are coupled to power-take-in on the gearboxes for a diesel-electric propulsion mode. The result is a very fuel-efficient vessel over the entire speed range.

As Bruno Bouckaert, the company's sales director explained, reducing pitching, heaving, rolling and yawing is highly desirable for naval vessels, as it improves operations such as launching and recovering helicopters and rigid hull inflatable boats (RHIBs). However, as Bouckaert notes, fuel efficiency is high on the agenda of navies these days, just as it is on commercial vessels.

Working with the Defence Materiel Organisation (DMO) of the Royal Netherlands Navy, Van Oossanen first conducted a computational fluid dynamics (CFD) study to see what potential the Hull Vane might have. As Bouckaert explained, the Royal Netherlands Navy recently imposed challenging goals for its entire fleet, including a substantial reduction in emissions and an even more significant increase in energy efficiency. Hence the DMO's interest in the Hull Vane.

As with other fuel saving devices, such as the bulbous bow, the Hull Vane is optimised for one speed, after which the savings can be determined for other speeds. In this case study, the decision was made to optimise the Hull Vane for the speed at which the ship in question consumes most fuel on an annual basis. DMO provided a theoretical and measured operational speed profile and Van Oossanen opted to use the measured operational profile for the study, even though it is less beneficial to the application of the Hull Vane, due to a lower average speed. The DMO also provided the speed/power curve of the vessel, which allowed Van Oossanen to calculate fuel consumption in each condition over the year. For each range of speeds, the average speed was used for the calculations. The lowest speed was set at 5knots, while the highest speed was set at 22.5knots. For each speed, the percentage of annual fuel consumption spent at this speed was calculated. It became clear that even though the vessel spends only around 13% of its time at speeds between 15 and 20knots, this was the condition at which almost half of fuel used per annum was consumed (48.7% of the total). It was therefore decided to optimise the Hull Vane for a speed of 17.5knots. To quantify the impact of the Hull Vane on operability, one seakeeping case was analysed using a

CFD study in regular waves. A comparison was made between the behaviour of the benchmark OPV and the OPV with modified trim wedge and added Hull Vane.

Helicopter operations are carried out by the Holland-class ships in conditions of up to and including Sea State 5. The impact of the Hull Vane on vertical accelerations due to pitching was evaluated when sailing at 20knots in a head sea, with regular waves with a height of 2m and a wave period of 8 seconds, resembling a typical North Atlantic wave condition (the Holland-class OPVs are often employed as coastguard vessels around the Caribbean islands of Aruba, Curaçao and Saint Maarten). As highlighted above, experience has shown that the Hull Vane also has a beneficial influence on the rolling motions at speed (like bilge keels) and on yawing motions, which would provide additional benefits for helicopter operations, however quantification of these effects was not part of the study. Van Oossanen suggests that a follow-up study could include an analysis at speed in bow or stern-quartering waves. RHIB launch and recovery through the slipway is currently carried out at forward speeds of approximately 5knots. From the CFD study for resistance, a graphical representation of the wake at 5knots could be extracted, allowing for a visual comparison of the benchmark vessel and the Hull Vane-equipped vessel.

As the vessel has a pronounced trim wedge – which is incompatible with a Hull Vane – so the trim wedge was partially modified to the limits set by the DMO. Subsequently, CFD runs were done to determine the resistance at 5knots, 12.5knots, 17.5knots and 22.5knots, showing resistance reductions of 1.3%, 13.7%, 15.3% and 11.1% respectively. Multiplied by the operational speed profile, this results in an annual saving on fuel and emissions of 12.5%. This translates into CO_2 emissions of more 1,000tonnes per ship per year, making the Hull Vane an extremely cost-effective CO_2 abatement measure.

To determine the influence of the Hull Vane on operability a seakeeping analysis was carried out in typical wave conditions. This showed a reduction of pitching movements of 7% and a reduction of the vertical accelerations on the helicopter deck of 13%. As the vertical accelerations are the limiting factor for helicopter operations, this will enlarge the operational envelope of the vessel.

The Hull Vane was tested on one of four Holland-class OPVs in the Royal Netherlands Navy

The turbulent wake zone behind the stern was reduced by about 50%, making the launching and recovery of the RHIB through the stern slipway safer and easier. Because of the reduced fuel consumption, the range of the vessel increased by 17% from 5,000nm to 5,850nm.

Given that the savings are greater and the cost lower in the case of a newbuilding; the DMO has already indicated that it will also consider the Hull Vane for future newbuilds. Overall, says Van Oossanen, the top speed of the vessel was slightly increased, from 21.5knots to 22.1knots, with the Hull Vane fitted, and the range of the vessel increased from 5,000nm (at 15knots) to 5,850nm (at 15knots). "Both of these higher values can provide significant tactical advantages," said the company, noting that the initial investment to retrofit a Hull Vane to the

Modifying the vessel

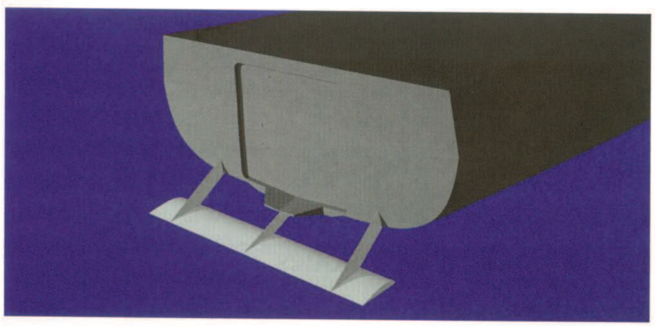
The hull of the Holland-class OPVs is fitted with a trim wedge over the entire breadth of the transom. The purpose of the trim wedge is to create vertical lift, which is required for the top speed of the vessel. As an alternative to trim wedges, many ships are equipped with stern flaps, ducktails or interceptors.

As a trim wedge directs the water flow downwards, and a Hull Vane works by generating forward thrust out of the upward flow, the base lines plan of the ship was modified by removing a part of the trim wedge. In the central part, about 50% of the depth of the trim wedge was removed, while on the sides it was slightly more. A larger part of the trim wedge was conserved in the central part, as this was needed to keep clear of the slipway. On the sides the modification was limited to keep clear of the swing area of the rudders.

The consequence of this modification was that retrofitting a Hull Vane to the Holland-class OPV required dry-docking. However, Van Oossanen believes that the modification can be completed within a scheduled dry-docking period, and therefore would not cause additional 'off-hire' time.

Because the outer struts (placed in line with the main longitudinal girders) are positioned quite far apart, and due to the high lifting force on the Hull Vane, an excessive bending moment would be generated in the connections between Hull Vane and struts if only two struts were used. It was therefore decided to design a Hull Vane with a three-strut configuration.

On the ship's centreline, a small extension was created, consisting of a lengthening of the slipway surface on its upper side and a lengthening of the bottom surface on its lower side. This extension made sure that a RHIB launched and recovered through the slipway would never come into contact with the centreline strut, and that there was sufficient transversal steel structure to adequately support the centreline strut in an area with very limited height.



Computer-generated impression showing a Hull Vane on an OPV

vessels is relatively small, compared to the returns in the long term and that, whilst the Hull Vane is relatively easy to retrofit to existing ships such as the Holland-class OPVs, the advantages would be even greater in case of a newbuilding project. For naval ships with signature and shock requirements, the Hull Vane would obviously require more detailed studies than those performed to date.

Accounting for information provided by the DMO such as maintenance periods, annual number of days at sea, fuel consumption per day at sea and the cost of the fuel resulted in an estimated annual fuel consumption of approximately €2.54 million (US$2.83 million) per ship per year. Based on the measured operational speed profile, the Hull Vane saves 12.5% of this amount, which translates to €257,000 saved per year. Based on the theoretical operational speed profile, the percentage saving is higher because more high-speed time was estimated. The Hull Vane would then reduce fuel consumption by 13.1%, amounting to €270,000 per year. Because reducing the fuel consumption reduces emissions such as CO_2, NOx and particulate matter there is also a clear environmental benefit to the application of the Hull Vane – CO_2 emissions per vessel per year would be reduced by about 1,060tonnes. The four Holland-class OPVs were commissioned around 2011 and designed for a lifetime of 30 years. This means that each of them has a remaining lifetime of at least 25 years. The required time for maintenance and capability upgrades means that only 87.5% of the remaining lifetime will be used in service, thus bringing the remaining active service time of each vessel to about 22 years. Based on the abovementioned fuel costs this means that the Hull Vane would generate fuel cost savings of €5.65-5.92 million per ship, or €22-24 million for the fleet of four vessels, based on the current fuel prices. *WT*