

TECHNOLOGY

Integrating propeller, bulb and rudder system saves fuel

Interaction between hull, propeller and rudder is complex, but attention to smoothing the flow in the hydrodynamic sense can improve propulsive efficiency and fuel consumption.

For several years Rolls-Royce has been using its excellent design and test facilities to study the interaction between hull, propeller and rudder. The result is an innovative Rolls-Royce propulsion system, which is initially being promoted for single-screw vessels operating up to 17 knots.

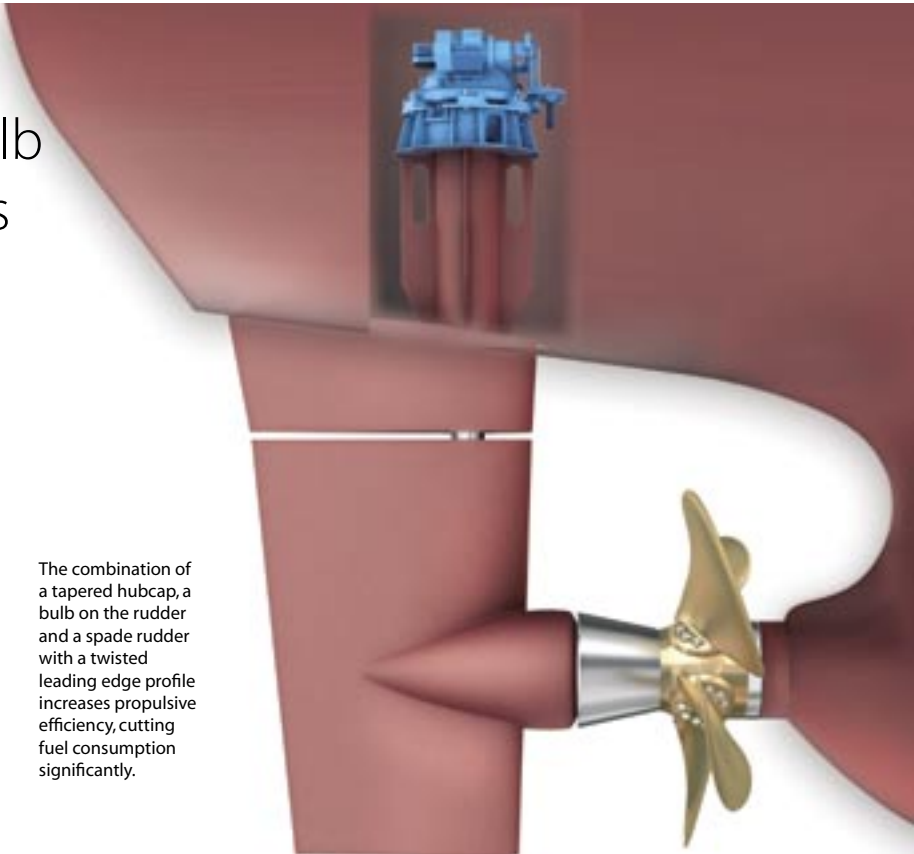
The system comprises a 'bulb hubcap twisted rudder' and uses a combination of features designed to smooth the flow of water from the propeller as it passes over the rudder. As the illustration shows, a tapered hubcap is fitted to the hub of the propeller and this leads the water flow on to a bulb which forms part of the spade rudder.

Propeller slipstream does not run straight aft: it has a swirl component because of propeller rotation. Energy in the swirl is often lost in conventional propulsion systems, but by twisting the leading edge of the rudder, the rudder forms a cambered hydrofoil profile, enabling some of the swirl energy to be converted into additional forward thrust which in turn helps to propel the vessel.

Bulb rudder solutions are of course not new. The difference here is the integration of propeller, bulb and rudder. The design brief stipulated that the system should work efficiently not only with the rudder set straight ahead but also during normal course corrections which involve rudder angles of typically 1-4 degrees, and additionally when the rudder is put hard over during low speed manoeuvring. Manoeuvrability should be improved across the speed range, primarily because the twisted rudder delays flow separation for a given speed and helm angle, and creates a higher side force (15% increase) during low speed manoeuvring.

The aim with Rolls-Royce propulsion systems is always to reduce noise and vibration. With the proposed system, pressure pulses from the propeller can be reduced. Because of the presence of the hubcap and bulb, the risk of hub vortex cavitation is removed. Consequently the radial distribution of hydrodynamic loads on the propeller blades can be modified, increasing the loading in towards the hub and reducing the loading at the tips, which helps to cut the intensity of blade pressure pulses.

Design calculations have been verified in the Rolls-Royce hydrodynamic research centre cavitation tank in Sweden. In particular, the interaction between the hubcap and the



The combination of a tapered hubcap, a bulb on the rudder and a spade rudder with a twisted leading edge profile increases propulsive efficiency, cutting fuel consumption significantly.

SOME OF THE SWIRL ENERGY IS CONVERTED INTO ADDITIONAL FORWARD THRUST WHICH IN TURN HELPS TO PROPEL THE VESSEL

curved leading edge of the bulb have been studied at different loading conditions and rudder angles. In theory, the gap between the hubcap and the forward part of the bulb should be as small as possible. In practice there has to be a gap sufficient to allow for structural deflection under load of the propeller aperture and rudder and also the tolerances that can be realistically achieved under real shipbuilding conditions.

Savings in fuel consumption can be considerable. As Göran Pettersson, project leader, observes: "for a typical merchant ship hull operating at up to 17 knots, the improvement in efficiency should be in the 3 to 6 per cent region, giving a payback time of one to two years. In due course we plan to offer the system for faster vessels up to about 21 knots. The percentage efficiency improvement for faster twin-screw vessels will be smaller, but still significant. These vessels typically burn much more fuel in the course of a year and we anticipate a payback time of about two years, depending on the hull design and the operating profile of the ship in question."

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