Introducing a New Product and Technology

Developing an Energy-saving Rudder with Bulb Fins
~ Achieving both Steering Effectiveness and Energy-saving ~

Yoshikazu Tanaka, Isao Yoshino, Akira Taniguchi - R&D Promotion Office
MOL Techno-Trade Co., Ltd.

1. Introduction

MOL Techno-Trade Co. Ltd. (MOLTech), a group company of Mitsui O.S.K. Lines, Ltd. (MOL), MOL, Japan Hamworthy Co., Ltd. (JHC), and Akishima Laboratories (Mitsui Zosen) Inc. (Akiken) have teamed up to conduct research and development on a propeller-mounted energy-saving device called PBCF (Note 1) and the energy-saving rudder with bulb fins.

The joint development of this innovative rudder leverages the expertise of MOL, Akiken, and MOLTech, which have developed and refined the PBCF for over 30 years, with the know-how of JHC, a specialized manufacturer of high lift rudders, to improve not only ship maneuvering performance but also horsepower with higher energy efficiency while maintaining the steering effectiveness of the schilling rudder. With an eye toward the autonomous vessels of the future as well as the potential applications on both oceangoing ships and coastal vessels, we plan to begin sales of the energy-saving rudder with bulb fins in 2021. While we are currently fine-tuning its performance, we will explain the past results of our R&D efforts below, as we obtained good results on energy-saving performance of this device.

2. Characteristics of the energy-saving rudder with bulb fins

1) To recover the swirling flow of the propeller, the reaction shape is designed as a high thrust blade section and the rudder horn is twisted and integrated to increase thrust due to negative pressure on the front edge of the rudder.
2) Decreasing the size of the end plate under the rudder reduces resistance and blocks propeller swirl flow.
3) The large central bulb has a flat front surface to reduce propeller inflow speed and improve propeller efficiency.

3. Overview of R&D

In our quest for the optimal energy-saving rudder with bulb fins, we conducted parameter studies as shown in Chapter 4 with computational fluid dynamics (CFD) calculation and a towing tank test, targeting a Japan Bulk Carrier (JBC) hull, a general enlarged ship design that is widely used in various research and development, and an Over Panamax car carrier as the fine ship. First, we narrowed down the combination of

(Note 1) PBCF: Propeller Boss Cap Fins. A device attached to the propeller of a vessel. It breaks up the hub vortex generated behind the rotating propeller (resulting in energy savings of 3% to 5% compared to an identical vessel not equipped with PBCF).

optimal parameters by various CFD parameter studies and confirmed the results by tank tests.

Generally, it is difficult to improve the horsepower by 4% or more with a normal reaction rudder. However, with this newly developed rudder, CFD showed a 5.7% improvement in horsepower and a self-propulsion test in a large towing tank confirmed a 5.2% improvement.

The rudder has been applied to fine ships as well, and CFD confirmed an energy-saving effect of 4.4%.

4. CFD and water tank test

We will introduce some of the CFD computation and tank test results as follows:

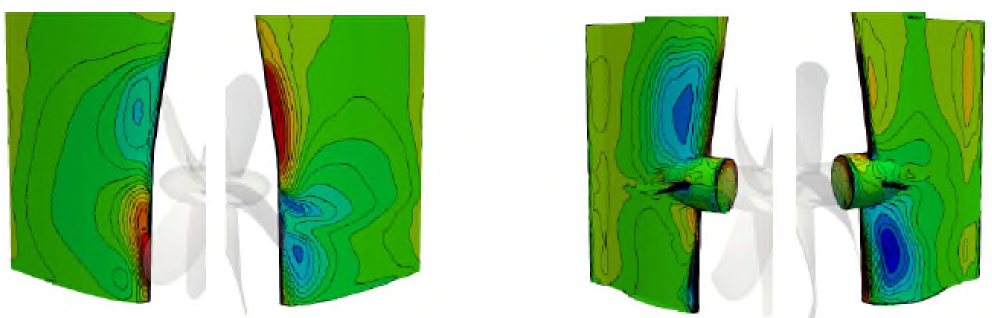
1) CFD of a JBC hull

We conducted various CFD computations in combination with the following parameters to narrow down the optimal energy-saving rudder with bulb fins.

(Examination parameters of the energy-saving rudder with bulb fins)

- With and without PBCF
- PBCF cap shape (shell type/cylinder type)
- Conventional rudder/schilling rudder
- With and without reaction of schilling rudder, reaction angle
- With and without skeg in the rear of the schilling rudder horn
- Length of schilling rudder lower end plate
- With and without flow regulating plates in upper shilling rudder
- Diameter of rudder bulb
- Shape of rudder front edge
- Fin shape (NACA symmetry/ asymmetry blades)
- Fin angle, length

Fig. 1 shows pressure distribution in CFD on the rudder surface of the JBC hull. At left is the CFD result of a conventional rudder, and at right is that of the energy-saving rudder with bulb fins. The pressure change (red and blue color indicates positive and negative pressure respectively) on the rudder surface is caused by the rotation of the propeller. In other words, it flows in from the port side at the upper rudder and from the starboard side at the lower rudder. Pressure resistance of the energy-saving rudder with bulb fins is small, with outstanding negative pressure on the front edge.



(Starboard side) Conventional rudder (Port Side)　　(Starboard side) Energy-saving rudder with bulb fins (Port Side)

Fig. 1. Pressure distribution on rudder surface of JBC hull in CFD

(Red and blue color indicates positive and negative pressure respectively)

2) Tank test of JBC hull

Using the JBC hull, we conducted resistance and self-propulsion tests and velocity measurement on stern by stereo particle image velocimetry (SPIV) in a large towing tank at Akiken. The various energy-saving rudders with bulb fins including a conventional rudder were narrowed down for selection by CFD. The energy-saving effect of the newly designed rudder, as measured in the tank test, almost matched the CFD result.

An example of the energy-saving rudder with bulb fins is shown in Fig. 2.

Fig. 2. Model of the energy-saving rudder with bulb fins

In addition, we conducted SPIV measurement tests to understand the mechanism of performance improvement and CFD verification. The SPIV measurement device is shown in Fig. 3, the photo during SPIV measurement in Fig. 4, and the result of velocity measurement in Fig. 5. We can expect more findings that will further improve the rudder’s performance, as well as continued improvements in the estimating and verifying performance using CFD, verified and compared with SPIV results at the flow distribution level.

Fig. 3. SPIV measurement device

Fig. 4. Photo during SPIV measurement

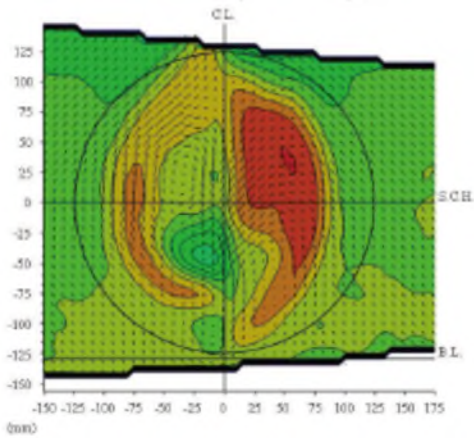
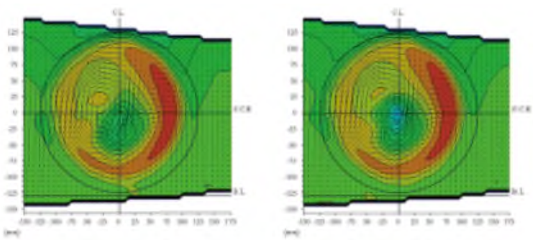


Fig.5. Result of velocity measurement (the energy-saving rudders with bulb fins)

(Red and green color indicates high and low speed range respectively)

3) Tank test using a JBC hull (PBCF unit test)

In the SPIV measurement of the PBCF unit shown in Fig. 6, you can see that the swirling flow behind the cap, which is seen in “without PBCF,” was eliminated and no longer evident in the “with PBCF” view.



(Without PBCF) (With PBCF)

Fig.6. Result of flow speed measurement (PBCF unit test)

(Red and blue color indicates high and low speed range respectively.)

4) CFD using a car carrier

Based on findings gained by examination of a JBC hull, we conducted the same parameter study about optimization by CFD of the energy-saving rudders with bulb fins on the fine ship.

Fig.7 shows the flow speed distribution at the propeller position in towing conditions and pressure distribution on the rudder surface. Red color indicates the range of high speed/high pressure, and the range of blue color indicates low speed/low pressure.

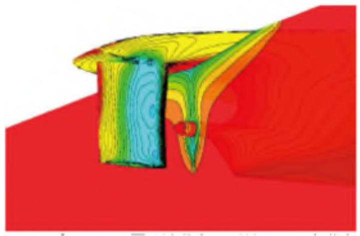
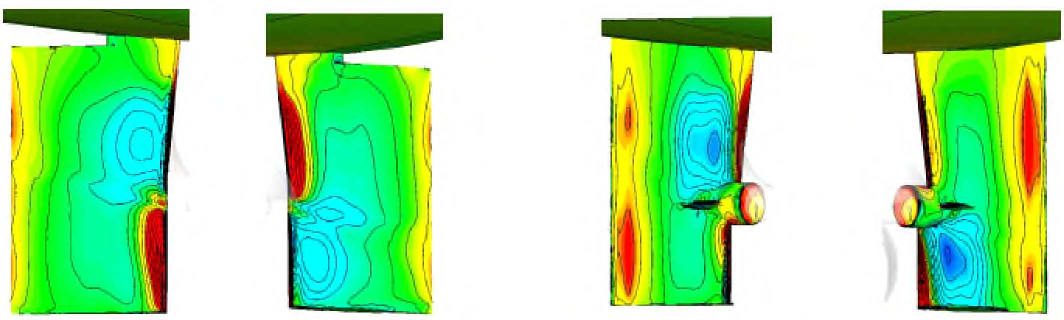


Fig. 7. Flow speed distribution at the propeller position in towing conditions and pressure distribution on the rudder surface

In addition, Fig.8 shows pressure distribution on the rudder surface by CFD. At left is the result of CFD for the normal rudder, and at right that for the energy-saving rudders with bulb fins on the fine ship. In the energy-saving rudders with bulb fins, the positive pressure range in the front of the rudder decreased and the negative pressure range increased. This contributes to higher propulsive force.



(Starboard side) Conventional Rudder (Port side) (Starboard side) Energy-saving rudder with bulb fins (Port side)

Fig.8. Pressure distribution by CFD on the rudder surface on car carrier

(Red and blue color indicates high and low pressure respectively.)

5. Conclusion

As an upgrade of the schilling rudder, we developed energy-saving rudders with bulb fins that improve ship maneuvering and energy-saving performance (improving horsepower) while maintaining steering effectiveness. As we move toward installation on in-service vessels, we will also confirm not only the synergistic effect with PBCF, but also the effect with ducts and pre swirl fins. Meanwhile, we have acquired a patent on the energy-saving rudders with bulb fins.

Finally, to our joint study partners—MOL, JHC, and Akiken, we truly thank you from the bottom of our heart.