

# Contributing to Society with the Environmentally Friendly PBCF

## Reduces annual CO<sub>2</sub> emissions by 9,000 tons per ship

Over 35 years since PBCF was first introduced in the shipping industry, we have seen a noticeable reduction in ship fuel consumption with large container ships cutting their annual CO<sub>2</sub> emissions by 9,000 tons or more when adopting our PBCF technology. As regulations surrounding CO<sub>2</sub> emissions continue to gain speed, our improved PBCF functions as an energy-saving device by ensuring increased reductions in both CO<sub>2</sub> emissions and fuel consumption rates.

## Selected for Equipment Designated by the Port of Vancouver EcoAction Program



The Vancouver Fraser Port Authority in Canada has selected PBCF as an underwater noise reduction technology for vessels as part of their EcoAction Program. The program offers vessel operators discounted rates on harbor dues if voluntary emission reduction measures or other environmental practices have been implemented. As of January 1, 2017, vessels with PBCF that call the Port of Vancouver are eligible for bronze level recognition and a 23% discount on harbor dues. PBCF not only saves energy, but it also contributes to environmental protection in a number of other ways, including protecting whales and other marine mammals by reducing underwater noise.

## Participated in Green Award Marine Environmental Protection Program Run by Green Award Foundation

MOL Techno-Trade, Ltd. has joined a Green Award Program as an incentive provider aimed at promoting high-quality and eco-friendly shipping since February 2019. Vessels and shipping companies that have acquired Green Award Foundation certification receives 3% discount from contract price of PBCF.



## Received the 2017 Nikkei Global Environmental Technology Award and the Award for Logistics Environmental Impact-Reducing Technology Development in the 21st Logistics Environment Award

PBCF received the “2017 Nikkei Global Environmental technology Award” presented by Nikkei Inc. and won the “Award for Logistics Environmental Impact-Reducing Technology Development in the 21st Logistics Environment Award” as selected by the Japan Association for Logistics and Transport.



**PBCF—Simple and Tough—**  
Environmental Technology that Continues to Evolve.

PBCF was jointly developed by Mitsui O.S.K. Lines, Ltd. (MOL), West Japan Fluid Engineering Laboratory Co., Ltd., and Mikado Propeller Co., Ltd. (presently owned by Nakashima Propeller Co., Ltd.), and is currently being marketed by MOL Techno-Trade, Ltd. The advanced PBCF is jointly being developed by Mitsui O.S.K. Lines, Ltd. (MOL), Akishima Laboratories (Mitsui Zosen) Inc., and MOL Techno-Trade, Ltd.

The MOL Group will continue to contribute to environmental conservation at ports and at sea around the world. Furthermore, through new technology slogan “One mile ahead”, it will step up its efforts to ensure safe operations and lower environmental impact.



**MOL MOL Techno-Trade, Ltd.**

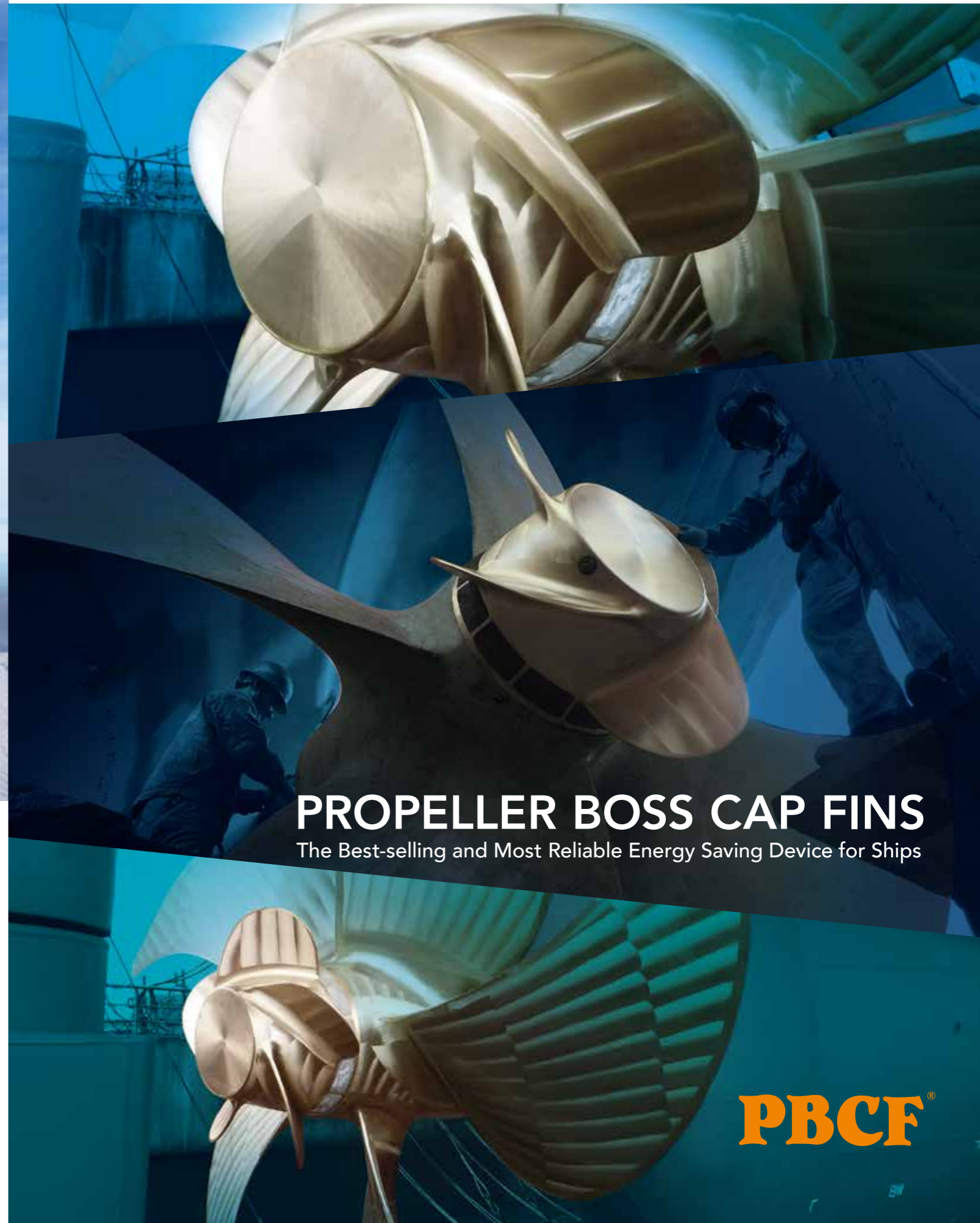
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**MOL MOL Techno-Trade, Ltd.**



**PROPELLER BOSS CAP FINS**

The Best-selling and Most Reliable Energy Saving Device for Ships

**PBCF**<sup>®</sup>

# Birth of a New Innovation —Advanced PBCF Following 37 Years of Experience and Trust

## What is PBCF?

Propeller Boss Cap Fins (PBCF) is a device that improves propulsive efficiency by recovering energy from the hub vortex generated behind a propeller. As a result, PBCF reduces fuel oil consumption. PBCF is the first energy-saving device developed with the aim of recovering energy by weakening the hub vortex. Its original design, as well as the technological innovation that has gone into its development, is highly regarded. Moreover, patents for PBCF have been obtained in various countries. Owing to continuous research and development, an achievement in itself, the advanced PBCF was released in May 2017. In addition, the new patents for the advanced type have been obtained in various countries.

As a pioneer in energy-saving device for vessels, PBCF has been installed on more than 4,200 vessels around the world since the technology was introduced in 1987. This is quite exceptional and reflects not only how effective PBCF is but also how well regarded it has become worldwide. Moreover, with the tremendous support of very reliable customers, PBCF has established a solid position in the industry.

### 5% Reduction in Fuel Consumption as well as Green House Gas Emissions

- Resolves the propeller torque rich condition, reduces underwater noise and stern vibration, and prevents rudder erosion

### Simple and Quick Installation, Regardless of Vessel Type or Size, and Suitable for Both New and Existing Vessels

- Vessel and propeller modifications are not required, and no welding work is necessary
- Can be installed on either a Fixed Pitch Propeller (FPP) or Controllable Pitch Propeller (CPP)
- Optimized design and custom made for every propeller profile
- No specific maintenance is required after installation

### PBCF remains effective over the lifetime of the vessel

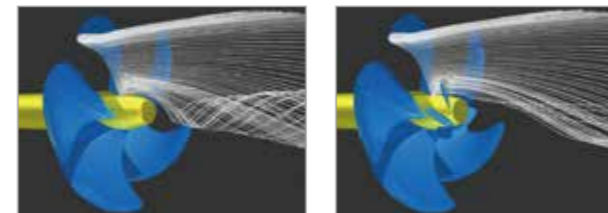


# The Advanced PBCF with Our Aim for Extensive Optimization

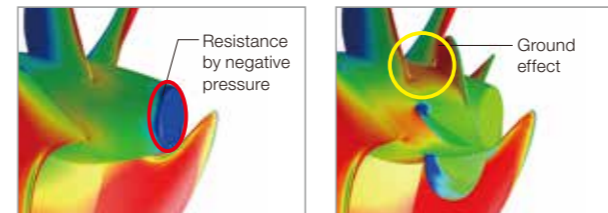
With extensive optimization and refinement of the fin shape, as well as adjustments to height, the advanced PBCF enhances propeller thrust and torque. Tests of the device on actual vessels have confirmed energy savings of around 5% compared to sister vessels without a PBCF. The advanced type is highly regarded as a breakthrough technology. Therefore its new patents have been obtained in a number of countries.

## CFD Analysis

Through ongoing research and development, the evolution of PBCF continues. Furthermore, a number of experiments on PBCF have been undertaken since the technology was first introduced. CFD analysis has enabled to clarify the streamlines behind the boss cap, pressure distribution, velocity distribution, and vorticity distribution after due consideration for the viscous effect around the propeller blades, fins, and boss surface. As shown in the figure, a significant difference of the pressure distribution on the surface and the aft end of the boss cap can be seen for cases with and without a PBCF. This demonstrates the supremacy of the advanced type from the viewpoint of hydrodynamic mechanisms.



The hub vortex is visualized by CFD simulation. Left: normal cap, Right: with PBCF



Pressure distribution showing low (blue) and high (red) pressures. Left: normal cap, Right: with PBCF

## Design Changes Lead to Big Savings

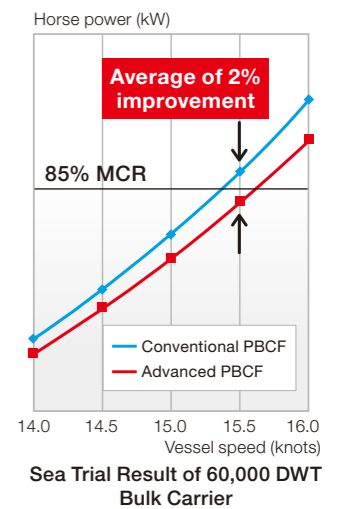
The extensively optimized design of the advanced PBCF allows for an additional 2% savings (average) in fuel consumption compared to the conventional type. Economic-related benefits for several types of ships are shown in the table. The payback period is within a year, even at times of low oil price rates, such as in recent years. In short, greater fuel savings can be expected by those using the advanced PBCF.

## Principles

PBCF is capable of reducing resistance by eliminating the hub vortex, increasing thrust with the ground effect, and gives the fins a strong push in the same direction as the main propeller rotation. After installing a PBCF, the hub vortex at the boss end will be reduced. This will result in a 5% increase in propeller propulsion efficiency, achieved through recovery of the energy loss caused by the hub vortex.

## Conventional vs Advanced on Actual Vessels

Evaluation tests, showing energy savings of around 3%, were conducted on more than 100 vessels equipped with a conventional PBCF. A comparative analysis of sister vessels, equipped with either a conventional type or an advanced type, was conducted to determine the effectiveness of the devices. The results show that the improvements in the advanced type make it more effective than the conventional type, on average by around 2% additional fuel savings.



### Payback period in less than one year

Vessel type	Fuel Oil Consumption	5% fuel savings with advanced PBCF	
		Payback Period (month)	Cost Savings (US\$/year)
Container (8,000 TEU)	100	1.7	\$1,100,000
VLCC	90	1.4	\$1,100,000
CAPE BC	60	1.9	\$650,000
HANDY BC	30	2.5	\$300,000

Note: Fuel oil price is VLSFO US\$800/MT, and figures for the fuel consumption rate are used in accordance with the actual state.