7,000 Vehicle Class Post-Panamax Energy-saving Pure Car and Truck Carrier "IRIS LEADER"

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In preparation for the opening of the new Panama Canal, the expansion of which started in 2007, new-generation post-Panamax PCTC (pure car and truck carriers) are beginning their maiden voyages. Iris Leader, completed in December 11, 2015, is a new-generation post-Panamax energy-saving car carrier owned by Nippon Yusen Kabushiki Kaisha. Its conceptual design and hull form development was undertaken by Mitsubishi Heavy Industries, Ltd. (MHI), and the following basic and detailed design and shipbuilding was handled by Imabari Shipbuilding Co., Ltd. This paper presents the latest new-generation post-Panamax PCTC as achievements of these efforts by the two companies.

1. Features of new-generation energy-saving car carrier

1.1 Principal particulars and general arrangement

Table 1 and **Figure 1** show the principal particulars and general arrangement of Iris Leader.

The principal dimensions of the car carrier were determined in consideration of a carrying capacity of approximately 7000 vehicles, and a 34.8 m-beam was adopted, which is somewhat smaller than the post-Panamax maximum beam of 160 ft (approximately 49 m) allowable for passing through the new Panama Canal. The length of the car carrier was set to less than 200 m to avoid the additional requirements for navigating in specified routes in Japan.

Based on these properly determined principal dimensions, despite the increased carrying capacity, Iris Leader can reduce the amount of ballast sea water for maintaining the stability performance of the vessel in comparison with existing Panamax car carriers. Furthermore, the latest hull form does not require a significant increase in the power of the main engine.

Four of the twelve car decks are liftable decks under which passenger vehicles, heavy-duty vehicles such as construction machines, and long cargo, etc., can be loaded. This achieves a cargo hold that can flexibly handle variations of transported cargo.

The rampway in the hold uses jumping slopes arranged in a straight line, resulting in a reduction of the cargo handling time. Pillars in the hold structure are arranged in a single line, and the car hold structure under the embarking deck adopts a newly developed structural form where no conventional transverse bulkhead for securing the structural strength is used. For this reason, vehicle maneuverability in the hold is significantly improved.

Table 1 Specifications of Iris Leader

Ship classification	NK	Main engine type	7UEC60LSE-Eco-A2
Country of registration	Japan	Main engine maximum output	13,800 kW x 105 min^{-1}
Overall length (m)	199.99	Generator	(Total) 4,180 kW
Breadth (m)	34.80	Diesel driven	4 sets
Depth (m)	38.07	Turbocharger driven	1 set
Full load draft (m)	10.60	Vehicle deck	12 layers
Car capacity (RT)	7,125	Liftable deck	4 layers
Ship speed (kt)	20.2	Shore rampway design load	
Dead-weight capacity (t)	20,853	Stern (t)	150
Gross tonnage	70,826	Middle of vessel (t)	20

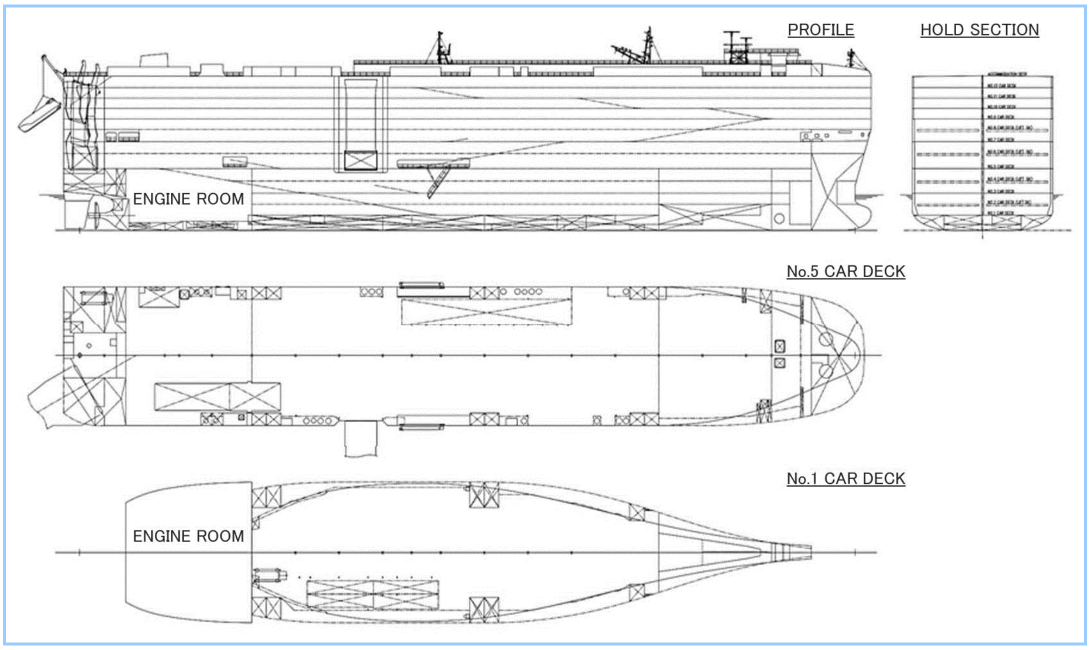

Figure 1 General arrangement

1.2 Energy-saving and global environmental-protection technologies

Figure 2 shows the energy-saving and global environmental-protection technologies equipped on Iris Leader.

As a result of the introduction of these technologies, Iris Leader attains energy saving of approximately 30% per a transported vehicle in comparison with existing Panamax car carriers.

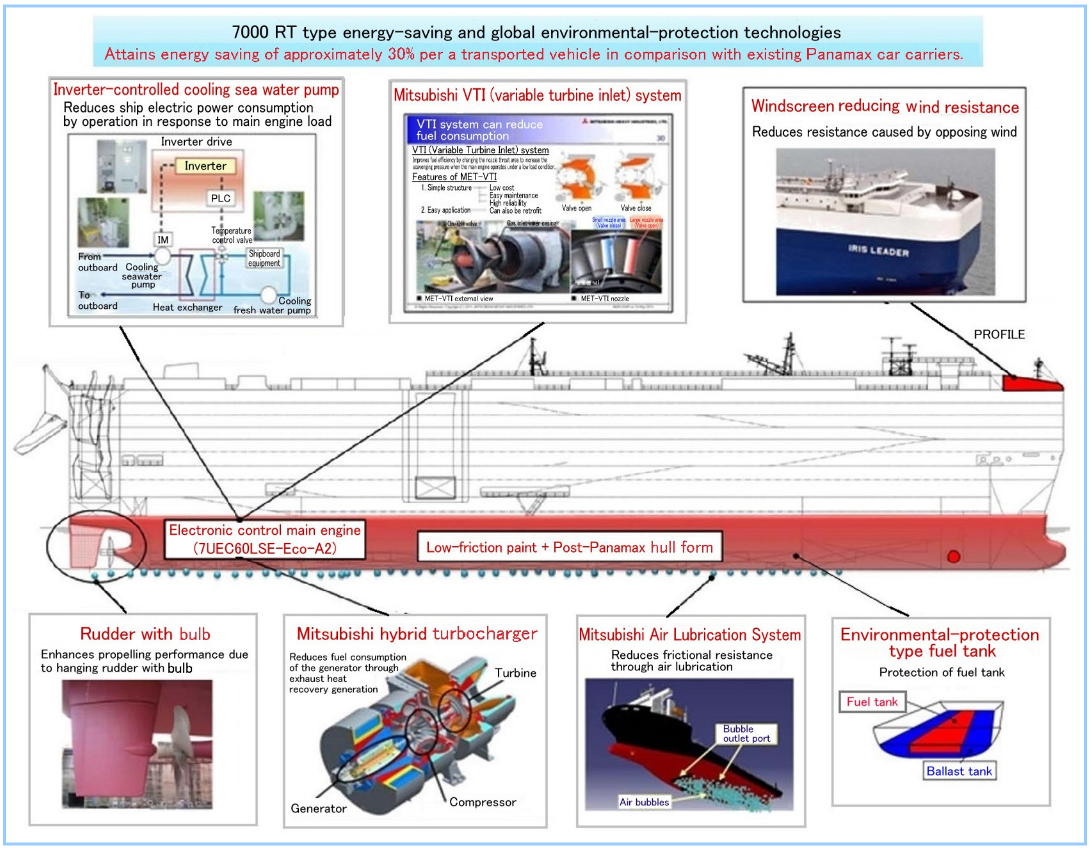

Figure 2 Energy-saving and global environmental-protection technologies

(1) Inverter-controlled cooling sea water pump system

The central cooling system (CCS), which is the main engine cooling system, uses an inverter-controlled sea water pump that can control the pump speed and amount of pumped sea water responding to the sea water temperature in order to reduce electricity consumption.

Figure 3 shows the structure of the inverter-controlled cooling sea water pump system.

The control valve opening range is automatically adjusted so that the cooling fresh water temperature becomes constant, and therefore varies in response to the sea water temperature and the ship thermal load. The fresh water temperature control valve opening signal is input to the control panel, the sea water pump speed is increased or decreased in response to the sea water temperature and the ship thermal load, and the pump discharge flow amount is continuously and optimally controlled. This keeps the opening of the fresh water temperature control valve within a certain range and attains energy saving.

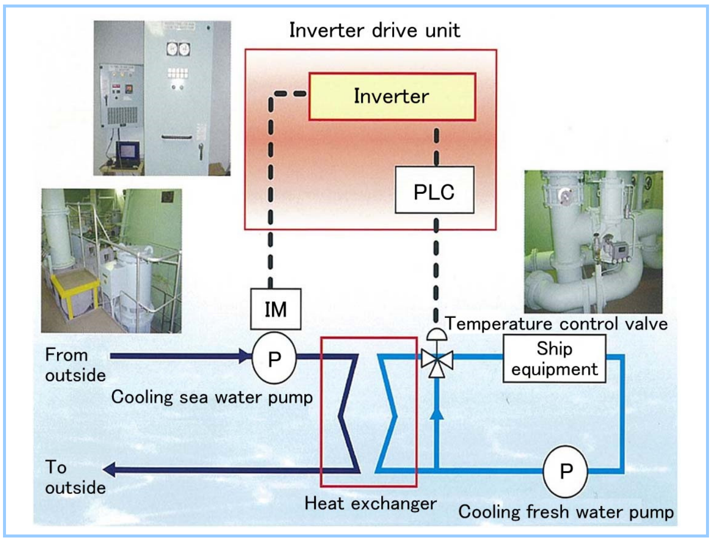

Figure 3　Inverter-controlled cooling sea water pump system

(2)　Mitsubishi VTI (variable turbine inlet) system

The service schedule of a ship is determined in response to seaborne cargo traffic. In some cases, where there is little seaborne cargo traffic, navigation at a reduced speed occurs. While a ship is navigating at a reduced speed, the main engine operates under a low load condition where the scavenging air pressure of the main engine decreases, resulting in lowering of the main engine operating efficiency. For maximizing and optimizing the efficiency during navigation at a reduced speed and under a low load condition, the variable turbine nozzle of the VTI (variable turbine inlet) turbocharger is installed to the exhaust gas inlet and changes the nozzle throat area. This results in improvement in fuel efficiency of 2 to 3 g/kWh. The VTI system has a simple and easy-to-maintain structure where the turbocharger main unit with a varying mechanism that switches the nozzle in two steps to reduce the nozzle area is used to increase the scavenging air pressure supplied to the main engine. **Figure 4** shows the nozzle opening and closing mechanism of the VTI.

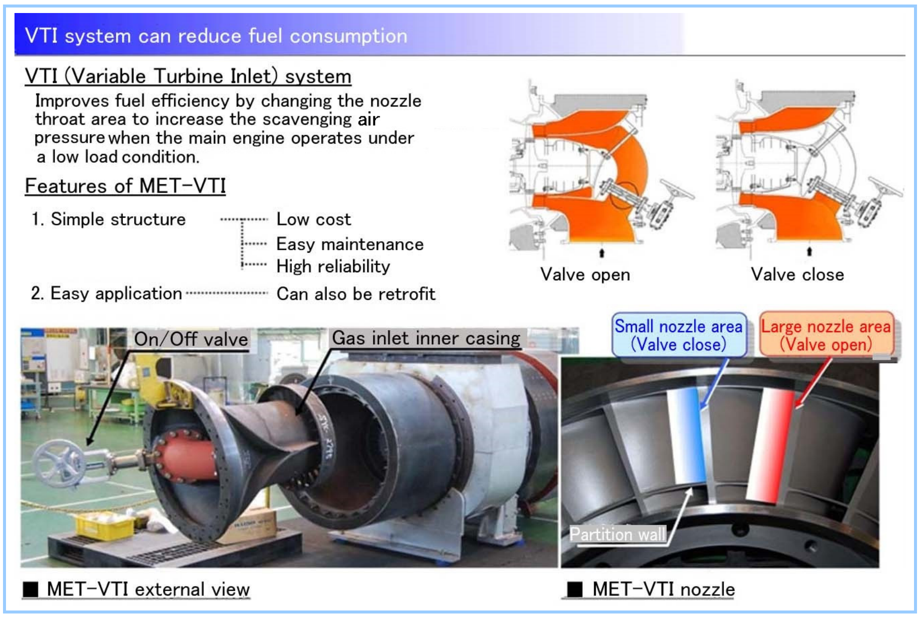

Figure 4　Mitsubishi VTI (variable turbine inlet) system

(3) Windscreen reducing wind resistance

Iris Leader is equipped with a windscreen that reduces the wind resistance caused by opposing wind from the front and the diagonal-front of the vessel. There is a concern that a screen installed in the near-front of the wheelhouse may affect the view from the wheelhouse. The windscreen equipped on Iris Leader, however, adopts a shape that minimizes the adverse effect on the view while maintaining the resistance reduction effect. **Figure 5** shows a bird's eye view of the windscreen.

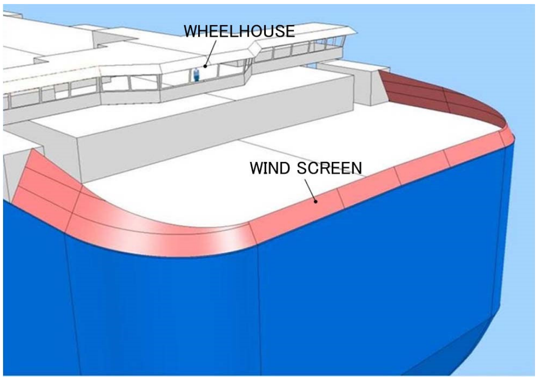

Figure 5 Windscreen reducing wind resistance

(4) Post-Panamax hull form equipped with reaction rudder with bulb

The hull form of the vessel was developed using the towing tank in the Fluid Dynamics Research Department of the MHI Research and Innovation Center with the full use of MHI's hull from development technologies and technological expertise accumulated over many years. In addition, a reaction rudder with a thin blade cross section was adopted as additional energy-saving equipment to further reduce rudder resistance and obtain a reaction effect of the rudder. Furthermore, the rudder bulb was installed at the rear of the propeller boss cap with the aim of enhancing the propulsive efficiency. Iris Leader was built before the enforcement of the IMO EEDI (Energy Efficiency Design Index) regulations. However, the statement of fact report issued by the classification society verified that Iris Leader attains an EEDI that is more than 10% less than the reference line of the regulatory requirements.

(5) Mitsubishi hybrid turbocharger

Iris Leader is equipped with a Mitsubishi hybrid turbocharger that recovers the exhaust gas energy of the main engine during navigation. **Figure 6** shows a cross-sectional view of the hybrid turbocharger unit. The hybrid turbocharger, a turbocharger combining an MET turbocharger and a high-speed motor/generator directly connected to its rotor shaft, feeds pressurized combustion air to the engine in a manner similar to a conventional turbocharger and simultaneously serves as a plant that generates electricity using exhaust gas energy. Furthermore, the generator can be used as an electric motor to accelerate combustion air supply instead of the auxiliary blower when the engine operates under a low load condition. In such cases, the required power is lower than that of the auxiliary blower and a higher energy-saving effect can be attained.

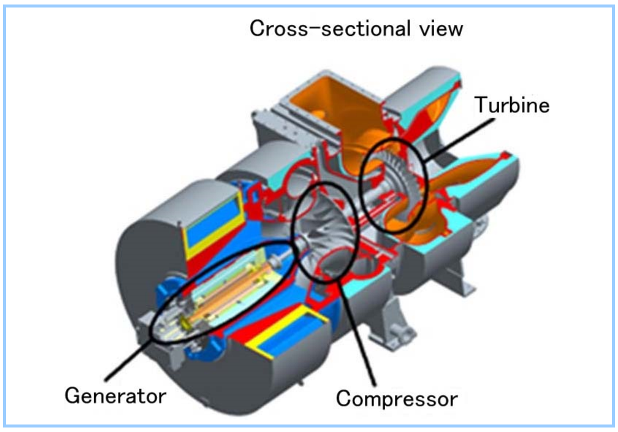

Figure 6 Mitsubishi hybrid turbocharger

(6) Mitsubishi Air Lubrication System (MALS)

Iris Leader is equipped with the Mitsubishi Air Lubrication System (MALS) in order to reduce main engine fuel consumption through a reduction in the frictional resistance of sea water on the vessel during navigation. MALS is a mechanism that blows air from the bottom of the vessel and carpets it with small bubbles to reduce resistance during navigation. In this case, the application target is car carriers with relatively fine hull form and smaller flat bottom. The sea trial results, however, showed an expected effect of MALS and verified its effectiveness. **Figure 7** shows the wakes generated when MALS is used and when it is not. This figure shows that when MALS is used, the bubbles blown from the bottom at the bow flow along the bottom surface to the stern without leaking out to the side and are released from the stern edge.

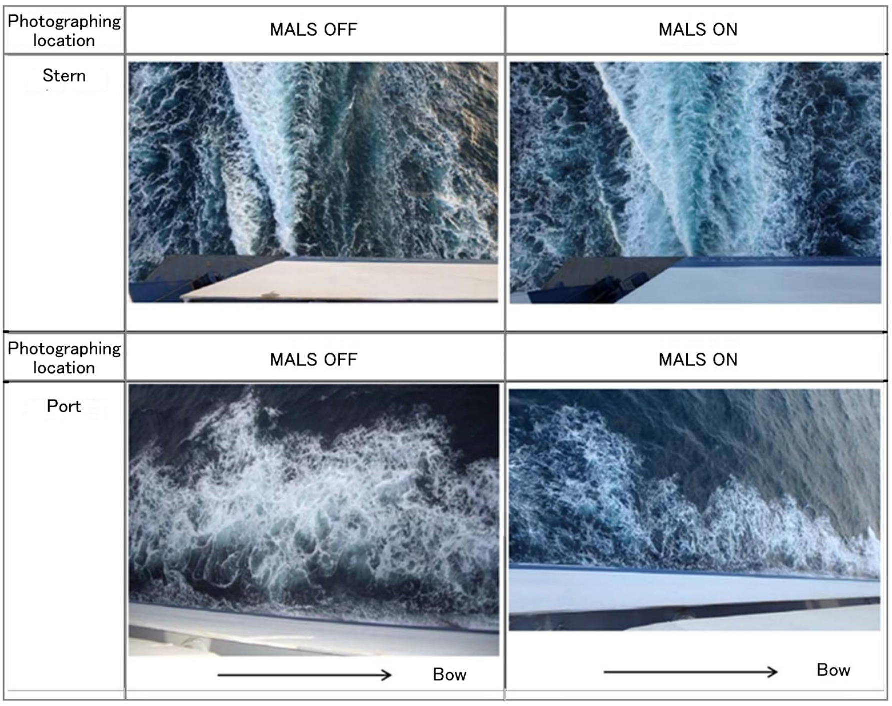

Figure 7 MALS wakes

(7) Environmental-protection fuel tank

The fuel tank is located at the bottom and is enclosed by the ballast water tank on the bottom outer panel side to reduce the risk of a fuel spill in the case of external damage to the bottom of the hull. This tank layout satisfies IMO regulations for the prevention of sea pollution by oil and contributes to environmental protection.