Mitsubishi Heavy Industries, Ltd., (MHI) has been providing environmentally-friendly Panamax pure car and truck carriers (PCTC). Now, we would like to introduce a new Post-Panamax PCTC in anticipation of the completion of the new Panama Canal in 2014 and also introduce our environmentally-friendly countermeasures to save energy in the carrier.

1. Main features of the Post-Panamax PCTC

Figure 1 shows the principal particulars of the Post-Panamax PCTC compared with the existing Panamax PCTC.

<table>
<thead>
<tr>
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<th>Conventional PCTC (Panamax)</th>
<th>Post-Panamax (for the new Panama Canal)</th>
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<tbody>
<tr>
<td>Overall length (m)</td>
<td>Approx. 200</td>
<td>Approx. 225</td>
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<tr>
<td>Breadth (m)</td>
<td>32.26</td>
<td>35.50</td>
</tr>
<tr>
<td>Depth (m)</td>
<td>34.50</td>
<td>39.00</td>
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<tr>
<td>Full load draft (m)</td>
<td>9.7</td>
<td>9.7</td>
</tr>
<tr>
<td>Car capacity (RT)</td>
<td>6,340</td>
<td>8,500</td>
</tr>
<tr>
<td>Main engine maximum output (kW)</td>
<td>14,315</td>
<td>15,400</td>
</tr>
<tr>
<td>Ship speed (kt)</td>
<td>20.35</td>
<td>20.0</td>
</tr>
</tbody>
</table>

Figure 1  New MHI environmentally-friendly Post-Panamax pure Car and Truck carrier
(1) Selection of Principal Dimensions

The principal dimensions of the post-Panamax PCTC are specified to be 35.5 m in breadth and 225 m in length. These dimensions are properly selected in consideration of economical ship performance to carry 8,000 cars (TOYOTA CORONA RT). The breadth is rather narrow compared with the allowable maximum breadth of 160 ft. (approx. 48.8 m) in the new Panama Canal, which will be completed in 2014. By selecting this combination of the length and breadth, it becomes possible to realize a more economical PCTC carrying 8,000 cars without drastically increasing the installed main engine power compared with current Panamax carriers with a carrying capacity of 6,500 cars. In addition, a drastic reduction of the loaded amount of ballast water while maintaining the suitable stability performance of the ship contributes to the achievement of a 20% reduction of main engine fuel consumption per vehicle from current Panamax carriers of 6,500 cars.

(2) Hybrid Power Supply System

MHI is now co-developing with Mitsui O.S.K. Lines, Ltd., and Sanyo Electric Co., Ltd., a hybrid power supply system combining solar power and lithium–ion rechargeable batteries as a technology development support program, part of the “Project to Develop Technologies for the Reduction CO₂ Emissions from New Ships” sponsored by Japan’s Ministry of Land, Infrastructure, Transport and Tourism. A Panamax PCTC of 6,500 cars with a co-developed hybrid power supply system will be delivered by MHI in 2012 to validate and assess its CO₂ reduction effect in actual operation. The aim of developing a hybrid power supply system is to achieve zero emissions in the future while the ship is in berth through the effective use of renewable energy. Electricity generated by solar panels is stored in the lithium-ion batteries while the ship is under way. The batteries supply power while the ship is in berth, allowing the diesel generator to be shut down.

(3) MHI Windscreen

The ship will be equipped with an MHI windscreen that reduces wind resistance from headwinds from the front in a diagonal direction. The effect of this windscreen varies in accordance with the shape of the main hull above the waterline and the arrangement of hull fittings such as the hold fan house and davits, etc.

It is expected to reduce the main engine power by 1% maximum in actual voyage.

(4) MHI Stator Fin

An MHI Stator Fin, an energy-saving device applicable to a high-speed slender ship, is installed to the rudder behind the propeller for recovering the rotational energy loss of the propeller.

A main engine power reduction of 3–4% is expected.

(5) Fuel Oil Tank with Marine Environmental Protection

Ship bottom fuel oil tanks are surrounded by ballast water tanks to comply with the International Maritime Organization (IMO) environmental protection regulations to reduce the risk of fuel oil outflow caused by external damage.

(6) Waste Energy Recovery Power Generating System for the Main Engine

It has become increasingly difficult for waste-heat recovery systems to supply shipboard electric services during voyages due to improvements in the propeller and hull form made to reduce the required propulsion power, as well as the NOx emission limitations of the IMO to reduce the exhaust gas energy. However, with recent improvements to the “MET-MA” high-efficiency turbocharger for the main engine, a portion (approx. 10%) of the exhaust gas at the turbocharger intake can be extracted. In order to recover waste heat as power, the extracted exhaust gas is;

A. mixed with the exhaust gas at the turbocharger outlet to increase the exhaust gas temperature and increase the steam turbine output in a conventional exhaust gas economizer turbo-generating (Eco-T/G) system, or

B. supplied to the power turbine, which assists the steam turbine, and then mixed with the exhaust gas at the turbocharger outlet to recover electric power, known as a super-turbo generating (STG) system (Figure 2).
A provisional calculation to compare the two systems was made for a Panamax 6,400 RT PCTC with a 7UEC60LSII-Eco main engine, with a maximum output of 14,315 kW (normal output 85%), which was NOx Tier II compliant. The results show that the STG system has more waste heat recovery to electric power output than the Eco-T/G system on the condition of the raised exhaust gas temperature after ship delivery. As for the point of the lowest limit of main engine output where the electric supply generated by the waste heat recovery system can cover the electric demand on board, the STG system has better performance. The electrical power output generated by the waste heat recovery STG system exceeding the electrical demand on board can be used for a shaft motor as an assist to the propelling power, but further investigation is required to evaluate the cost effectiveness between fuel saving and the additional cost of an assist motor system considering rising fuel prices in the future.

In order to realize more waste heat recovery, we are also investigating the Organic Rankine Cycle (ORC) by using a low-boiling agent and waste heat from lower temperature engine cooling water. Further study to select the proper agent and ensure compliance with the requirements of the Classification Society is required.
cooling seawater pump and a reduced pump speed when the seawater temperature and shipboard heat load are low.

Figure 3 shows the configuration of the inverter-controlled pump system (MESHIP), which was co-developed by MHI and MEC Engineering Service Co., Ltd. This system automatically controls the cooling seawater pump speed stepless by inverter controller to obtain the optimum required cooling seawater flow depending on the seawater temperature and shipboard heat load so that the temperature control valve opening range is constant within the predetermined range input from the control board. This system was installed in an MHI-built PCTC, and operational data were collected from February through to May 2009. The pump-rated input of 80.2 kW was reduced to 12.5 kW, and approximately 67.7 kW of energy savings were verified under a main engine load between 50 and 60% and seawater temperature of 15 to 28°C. The annual fuel consumption was estimated to be 1.6 ton/year · kW, and fuel savings of approximately 108 tons per year were expected.

![Figure 3  MESHIP system configuration](image)