New Generation LNG Carrier "SAYAENDO"

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In recent years, there has been increasing demand for LNG (liquid natural gas), as well as LNG carriers, both domestically and internationally, with environmental considerations and the shale gas revolution in the U.S. in the background. Mitsubishi Heavy Industries, Ltd. (MHI) has developed Sayaendo, a new generation LNG carrier, and is now receiving orders for its construction. In the midst of this, LNG VENUS, an LNG carrier for Osaka Gas Co., Ltd. and Mitsui O.S.K. Lines, Ltd., which was the first Sayaendo ordered, was completed. This paper presents an overview of Sayaendo together with its features.

1. Overview of Sayaendo

Sayaendo is a 155000m^3 MOSS type (spherical tank type) LNG carrier. In contrast to conventional MOSS carriers, the spherical cargo tanks of which are blanketed with separate hemispheric tank covers, Sayaendo has a continuous tank cover that covers the cargo tanks. The nickname Sayaendo comes from its exterior. This carrier, with a continuous cover and spherical tanks contained thereunder, looks like peas in a pod, known as sayaendo in Japanese.

The adoption of a continuous cover integrated with the hull reduces the weight of Sayaendo while ensuring overall structural strength. It also significantly mitigates wind pressure from the front, which becomes resistance to propulsion. The MHI Ultra Steam Turbine Plant (UST), which has higher thermal efficiency due to the reheating cycle, is used for the main propulsion plant. This plant, together with the effect of the continuous cover, contributes to the significant improvement of the fuel economy performance. In addition to the reduction of CO_2 emissions resulting from the improvement of fuel efficiency, Sayaendo has superb environmental friendliness, including being capable of 100% gas-fired operation for all operational areas and the reduction of surplus gas treatment amount due to the adoption of low boil off rate (BOR: index of gas amount generated by the introduction of heat) heat insulation.

2. Features of Sayaendo

The features of Sayaendo are described below.

2.1 Reduction of hull weight

Conventional MOSS type LNG carriers have separate hemispheric steel tank covers for aluminum spherical cargo tanks. In this case, the covers are additional components, and the structural strength is principally ensured by the main hull excluding the covers. Sayaendo has a continuous tank cover that covers four spherical tanks and which is integrated with the hull, contributing to the strength. As a result, both the improvement of overall strength and a drop in the hull weight due to the reduction of additional components are attained.

2.2 Improving transportation efficiency and securing operational versatility

Through the adoption of stretch tanks, which are extended upward with the same diameter as the spherical tank, Sayaendo attains an additional cargo capacity of 8000m^3 compared with MHI's conventional 147000m^3 carrier capacity with the beam unchanged, resulting in the improvement of

transportation efficiency.

Sayaendo has good compatibility with LNG terminals all over the world in consideration of use for various LNG trades. For this purpose, main dimensions that are approximately the same as MHI's conventional 147000m^3 carrier capacity are kept unchanged through the adoption of the continuous cover and the stretch tanks. Sayaendo also has main dimensions within the maximum shape (366m in length over all, 49m in width, and 15.2m of draft) for passing through the New Panama Canal, and therefore its operational versatility is high.

2.3 Improvement in maintainability

The adoption of the continuous tank cover allows for the simplification of a conventional MOSS carrier's complex structure above the tank cover that supports pipes, wires and pathways, resulting in a significant improvement in maintainability.

2.4 Improvement of fuel economy performance

Sayaendo is applied a newly developed optimal hull form that takes advantage of a reduction in the hull weight to enhance propulsion performance. In addition, the adoption of the continuous tank cover has reduced wind resistance while cruising. Furthermore, the UST is used as the main propulsion plant, resulting in an approximately 15% improvement in efficiency with the advantage of the conventional turbine plant unchanged.

2.5 Environmental consideration

In addition to the factors for improving fuel consumption described in 2.4, further improvement of propulsion performance using additional energy saving devices can reduce CO_2 per unit load in actual operation by up to approximately 25% in comparison with the conventional 147000m^3 MOSS carrier. Sayaendo also has environmentally-friendly specifications such as the reduction of NOx emissions using the UST, the capability of 100% gas-fired operation for all operations including while in-port, a decrease in the amount of surplus gas treatment due to the adoption of low BOR heat insulation, and the mitigation of the influence on marine ecosystems through the use of a ballast water treatment system.

3. LNG VENUS

LNG VENUS is the first of two of the same type of LNG carrier built for Osaka Gas Co., Ltd. and Mitsui O.S.K. Lines, Ltd., which were the first Sayaendo orders MHI received in October 2011. LNG VENUS was delivered in November 2014 after the verification of the design performance through a sea trial and a gas test in October 2014. **Table 1** shows the principal particulars and **Figure 1** shows the overall layout.

Table 1 Principal particulars of LNG VENUS

LNG tank type		MOSS type spherical tank (four tanks)
Cargo tank capacity (100% full, -163°C, atmospheric pressure, excluding dome space)	(m^3)	155,691
Nationality of ship		Japan
Classification		NK (Nippon Kaiji Kyokai)
Length, between perpendiculars	(m)	288.0
Breadth, moulded	(m)	48.94
Depth, moulded	(m)	26.0
Designed draught, moulded	(m)	11.55
International gross tonnage		136710
Service speed	(kt)	19.5
Main propulsion plant		Reheating marine steam turbine plant (MHI Ultra Steam Turbine plant)

The inside of the continuous tank cover is separated into four hold spaces. The cargo manifold for connection to ground terminals when loading and unloading is located between the No. 2 and No. 3 cargo tanks. There is a cargo machinery room at the top of the tank cover between the No. 3 and No. 4 cargo tanks.

This carrier is equipped with a reaction fin and a twist rudder with a bulb as additional energy saving devices for the improvement of propulsion performance. In addition, due to the adoption of a heat insulation system with a BOR of 0.08% per day, a significant reduction in

comparison with conventional carriers, economical operation can be performed at wide range of speeds. Furthermore, a rudder that can be steered up to 45 degrees during low-speed cruising, the bow thruster, and the helicopter deck improve in-port controllability and operability.

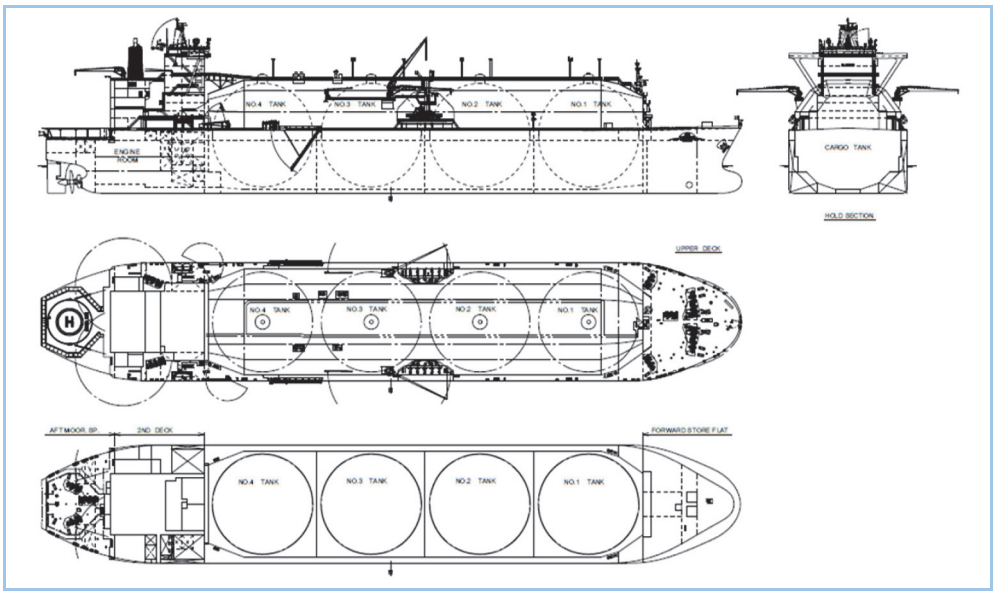

Figure 1 Overall layout

4. Future prospects

The high energy-saving performance and environmental friendliness of Sayaendo LNG carriers including LNG VENUS are attracting great interest from the shipping industry. MHI has been successfully receiving orders and building Sayaendo, which is one of the leading eco-ship products being actively developed in the Japanese shipbuilding industry. At MHI, eco-ship products including Sayaendo are positioned as added-value core products that the Ship and Ocean businesses focus on. MHI will continue to promote further technological development and the extension of the lineup, including the development of a new carrier to take advantage of shale gas opportunities in North America.