An 86,700 m³ LPG-fueled LPG/NH_3 Carrier

This LPG/NH_3 carrier can transport LPG, which is widely used as an energy source with low environmental impact, and ammonia, which is expected to be used as a new fuel in the carbon neutral society of the future. This carrier can use LPG as the main engine fuel. While maintaining the main dimensions of the conventional LPG carrier built in our shipyard, it features a larger cargo tank capacity and achieves the world's lowest level of fuel consumption.

Introduction

As one of the world's largest energy consumers, Japan has used LPG as clean energy in a wide range of areas, such as general households, taxies and industry. Very Large Gas Carriers (VLGC) that transport LPG are essential for Japan because most of LPG used in Japan is imported.

1 Background

Competition for orders is vigorous as an increasing number of VLGCs are being constructed not only in Japan but in Korea and China as well. In addition, to boost transportation efficiency, the VLGC becomes larger. As market trends are changing, we had to develop a new VLGC that customers like better than those of our competitors as quickly as possible.

We also reviewed the specifications for transporting ammonia, which has recently been gathering attention as a CO_2-free fuel.

2 Overview and features

Table 1 shows the principal particulars of this carrier, while **Fig. 1** shows the general arrangement. This carrier has the largest hull dimensions satisfied to main LPG terminals in Japan.

The carrier has three new features, namely lower fuel consumption than that of conventional ships, an enlarged cargo tank, and ammonia transportation capability. It also supports LPG fuel, which is more environmentally friendly than fuel oil.

(1) Low fuel consumption

We have improved the hull form to achieve best-ever propulsion performance by leveraging sea trial data we have accumulated. We also adopted newly developed energy-saving fins (short horizontal fins) (**Fig. 2 (d)**) in addition to our proprietary SEA-Arrow hull form (**Fig. 2 (a)**) and energy-saving devices (semi duct system with contra fins, rudder bulb system with fins) (**Fig. 2 (b)** and **(c)**) that we have adopted in conventional ships. We achieved the world's best fuel consumption level, improving fuel consumption by about 6% from the previous series of 84,000 m³ LPG-fueled LPG carriers by adopting a fuel-efficient main engine, in addition to the hull form improvement and energy-saving devices.

(2) Increase of cargo tank capacity

Many LPG terminals were designed in accordance with LPG hull dimensions that were available at the time when such terminals were constructed, and they are no longer optimal for today's larger hull dimensions. Therefore, if ship size is increased without careful

† A large LPG carrier that achieves significant reduction in environmental impact by using LPG as its main fuel through adoption of the ME-LGIP dual-fuel slow-speed diesel engine that can switch between LPG and fuel oil.

Table 1 Principal particulars

Ship type	Heavy oil/LPG dual fuel propulsion LPG/NH_3 carrier
Length overall × width × form depth [m]	Abt. 230×37. 2×21. 9
Cargo capacity [m^3]	86, 700
Service speed [knots]	17

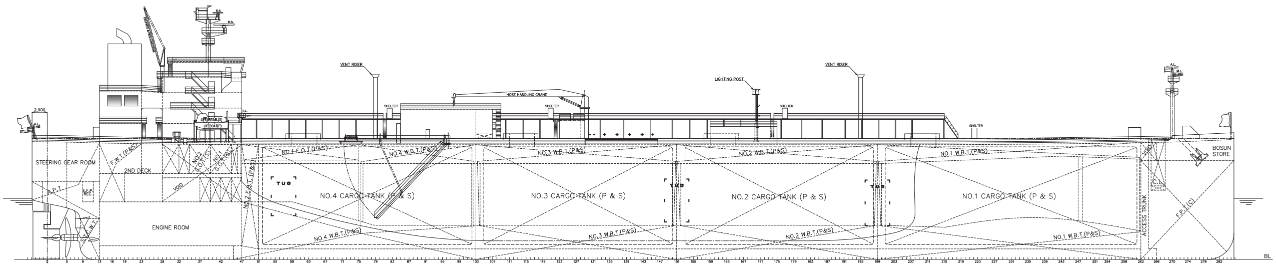
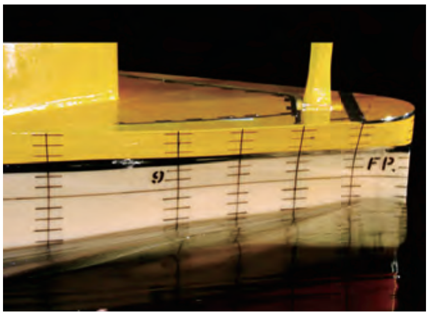


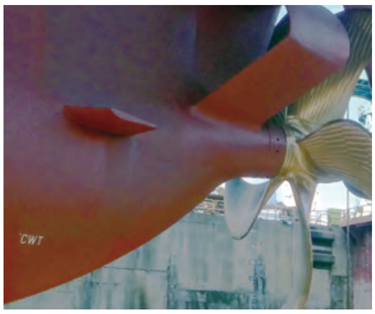
Fig. 1 General arrangement



(a) SEA-Arrow

(b) Semi Duct System with Contra Fins

(c) Rudder Buib System with Fins



(d) Short Horizontal Fins

Fig. 2 Bow form and energy-saving devices consideration, the resulting ship will encounter challenges. For example, the ship may not be allowed to land to important terminals or entry may be limited. Therefore, we decided to increase the cargo tank capacity without changing the main dimensions, based on which terminals may apply restrictions, so that the new carrier can continue to enter the same terminals as the previous series of 84,000 m^3 LPG carriers.

The cargo tank has the capacity to load an amount of LPG fuel sufficient for a round trip between Huston and the Far East and provides sufficient cargo capacity. The route between Huston and the Far East is one of the main routes. In addition, although LPG is often traded in lots based on cargo weight, the value has been changing over the decades. So, we have ensured a cargo capacity sufficient for the latest transaction lots.

(3) Support for ammonia transportation

We changed the specifications to load ammonia, which has recently been gathering attention as a CO_2-free fuel. We placed particular focus on corrosiveness, specific gravity, and operation.

Because ammonia may cause stress corrosion cracking of some materials, we changed the material to one that is resistant to it.

In addition, because ammonia in a liquid state has a higher specific gravity than LPG, we changed the specifications of the cargo equipment to handle this higher specific gravity. Furthermore, because ammonia in a gas state is lighter than air, unlike LPG, we installed safe equipment in the upper part of the area such as a cargo machinery room, in addition to the lower part of the area where the equipment is already installed for LPG.

For the operation of ammonia, we prepared necessary equipment according to our experience with the multi gas carrier we constructed about 20 years ago and various guidelines.

We not only changed the specifications to transport ammonia as cargo but partially acquired the ammonia fuel ready notation, a class that enables us to use ammonia as fuel for the main engine in the future, to further reduce CO_2 emissions.

(4) LPG fuel supply system

Since we constructed the first LPG fuel LPG carrier in Japan, the LPG fuel system has been the global standard for LPG carriers. We led the world in starting development of an LPG fuel system, in consideration of environmental impact, and we developed a proprietary LPG fuel supply system based on our knowledge of LPG carriers accumulated over the years and the LNG fuel systems we have already developed and implemented.

Fig. 3 shows an outline drawing of the LPG fuel supply system. The main features are the presence of a service tank and individual control of each line.

The service tank stores the minimum necessary amount of LPG to be used as fuel. In addition, the service tank prevents the cargo contamination if lubrication oil

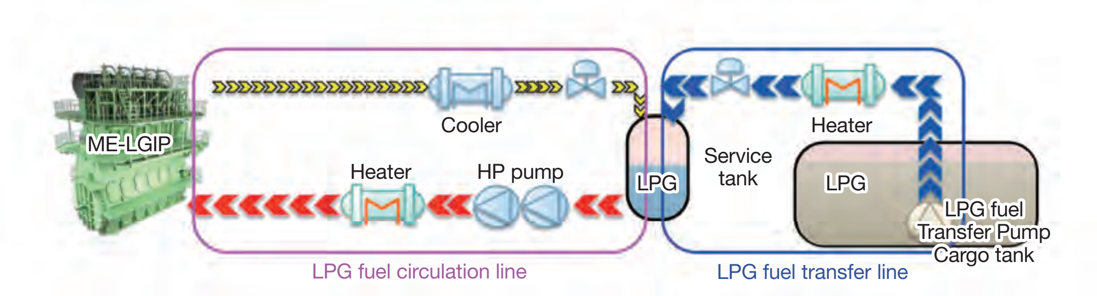


Fig. 3 LPG fuel supply system diagram

enters the cargo tank, as LPG returning from the main engine is contaminated with a small amount of lubrication oil. We developed the fuel supply system around the service tank to realize a simple control mechanism to individually control the fuel transfer line and the fuel circulation line.

We developed a control system for each line, repeating simulations with assumed temperatures and physical properties. We constructed a simple system that monitors LPG within the system to prevent it from boiling and maintains it in a liquid state with appropriate control equipment because LPG in a liquid state is supplied to the whole system.

Conclusion

This carrier has become a huge success compared to previous ships and is highly appreciated by many shipowners.

In order to contribute to the realization of a low-carbon and carbon neutral society, we will develop and provide environmentally friendly ship technologies starting with the 86,700 m^3 LPG/NH_3 carrier shown in the top photo in light of environmental restrictions, which are increasingly tightening around the world, and specific action plans as exemplified by the SDGs.

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