The first BOG reliquefaction system on board ship in the world "LNG Jamal"

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1. INTRODUCTION

Where do you think the LNG transportation business is headed for? And what would be the development in the LNG transportation technology? We believe the tanker 'LNG Jamal' has the key to these questions. We would like to introduce the LNG Jamal which is cruising all over the world with innovative technologies on board.

"LNG Jamal" equipped with 5 Moss-type spherical tanks (total capacity: abt. 135,000m^3) is a purpose built vessel for the Oman LNG project. She transports abt. 660,000 tons of LNG annually from Oman to Japan. She was delivered in October 2000 and has maintained excellent conditions. Changes in design of LNG vessels do not generally come easily, but the Jamal is a product of innovative new technologies brought in by every party, the ship owners, buyer, transporter and shipbuilder.

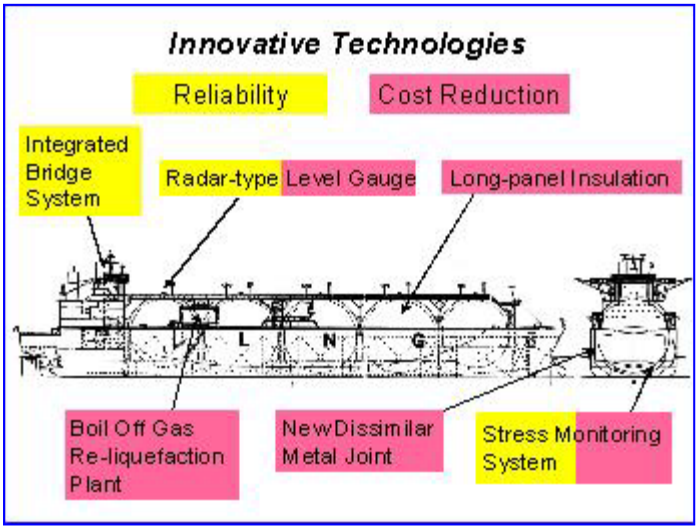
The following design concepts were applied in the design of the LNG Jamal.

1) A vessel to achieve economical and flexible transportation around the world
2) An advanced vessel adopting newest technologies

All of the principal performance including newest technologies of this vessel has been checked and we have confirmed that the vessel achieves higher than the design capacity/performance.

2. ECONOMICAL AND FLEXIBLE TRANSPORTATION AROUND THE WORLD

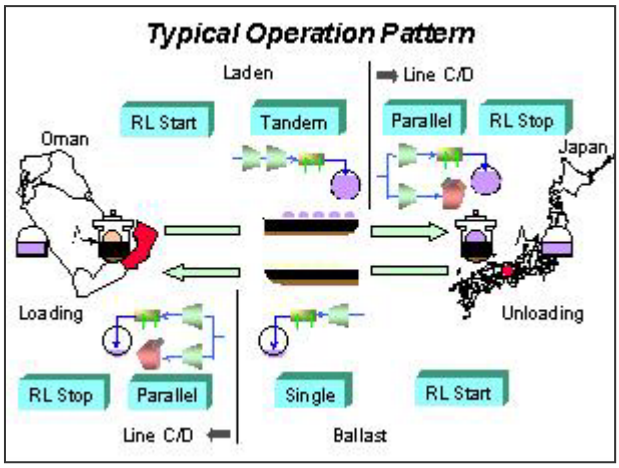
Most of the LNG vessels are dedicated to one particular LNG project. However, the LNG Jamal was designed and built with a ship-shore compatibility to all the major LNG terminals in the world. She has actually transported LNG to three countries other than Japan and undertaken discharging operation at Lake Charles Terminal in U.S.A, Yung An terminal in Taiwan and Inchon Terminal in Korea. As the Jamal is built with the main mission to serve the Oman project, she travels both eastbound to the Pacific region and westbound to the Atlantic to deliver LNG. She has now every LNG terminal in the world as her prospective destination.



On the other hand, the design of the LNG Jamal enables to change flexibly the mode of navigation and on board operation to maximize the economy based on such conditions as the LNG market, fuel costs and the transportation route. This flexibility can achieve lowest transportation cost for buyers. Since the BOG reliquefaction system is installed on board, when the LNG Jamal is to transport LNG to a certain location, we can choose the best fuel considering the navigation route, bunkering point, price of bunker and LNG. The automatically controlled BOG reliquefaction system makes it possible to easily switch the operation mode without giving extra burden on the ship's staff. We are very proud of the LNG Jamal with her innovative technologies to pursue maximum cost efficiency. LNG trading is expected to have greater flexibility in the future as that for oil and LPG. We are confident that the LNG Jamal can certainly bring our dream to reality.

3. ADVANCED VESSEL AGGRESSIVELY ADOPTED NEW TECHNOLOGIES

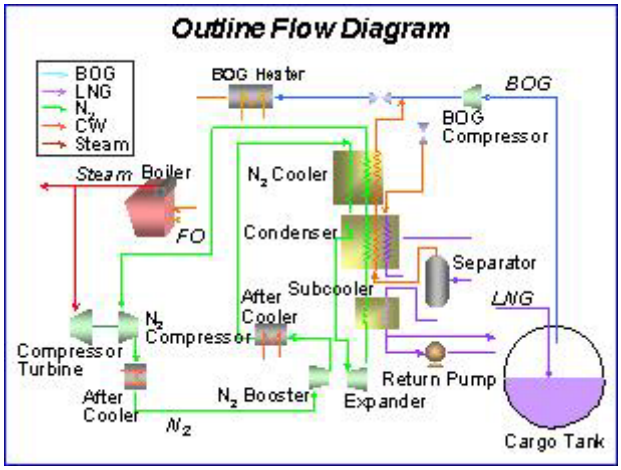
The following describes concrete examples of innovative technologies that were applied to the vessel.



3.1 BOG reliquefaction system

LNG Jamal is the first BOG reliquefaction system on board vessel in the world as LNG carrier. After her delivery October 2000, we had some very minor trouble for reliquefaction system. Since then, all of the issues are cleared and this plant shows excellent performance. We have confirmed that the reliquefaction plant is capable of automatic operation in the liquefaction rate range of 1 to 3 t/h.

For the LNG Jamal, a higher transportation capacity was achieved with the installation of BOG reliquefaction plant that reliquefies the generated BOG during voyage and this system contribute to achieve competitive transportation cost. Since the LNG Jamal has demonstrated the effectiveness of the reliquefaction plant as BOG processing equipment, it paved the way toward adopting new propulsion systems for LNG vessels that are more efficient than a steam turbine.

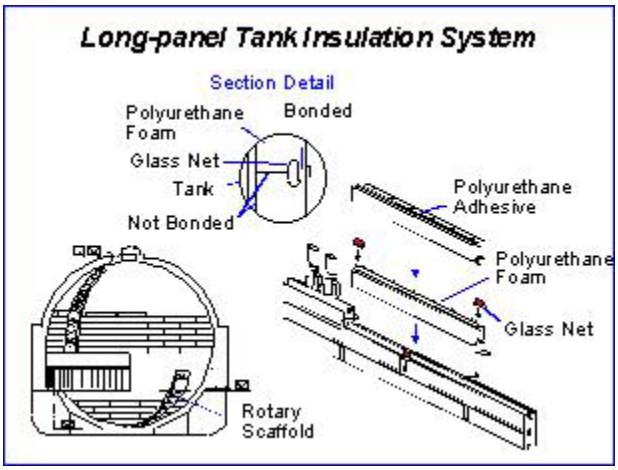


Normally, the steam turbine plant with relatively high fuel oil consumption rate has been applied on LNG vessels because of its high reliability, utilization of natural BOG as a fuel for propulsion. Successful operation of the reliquefaction system on board the LNG Jamal has created various new options in the propulsion system for the LNG carrier, such as the combined diesel engine and electric propulsion system. We are confident that installing the BOG reliquefaction system will provide cost efficient alternative, once all the necessary transportation conditions are satisfied such as the navigation route, bunker supply locations, fuel price, LNG price, initial investment and maintenance/repair costs.

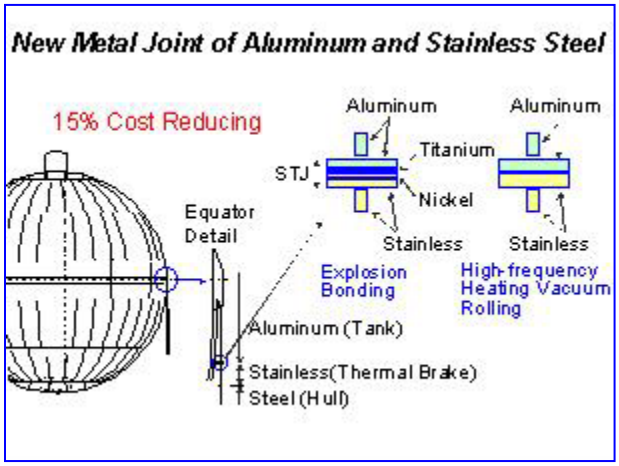
3.2 Long-panel Tank Insulation System

The present LNG carrier is the first to use the long-panel system throughout cargo tanks thus providing an extra reliability. We have not found any cold spot on the insulation and it achieves good boil off rate due to greater factory-produced content and few foaming on site.

This method has opened a way to a new future in the insulation technology and is expected to contribute to reducing the insulation cost as well as the construction period of the tanker.

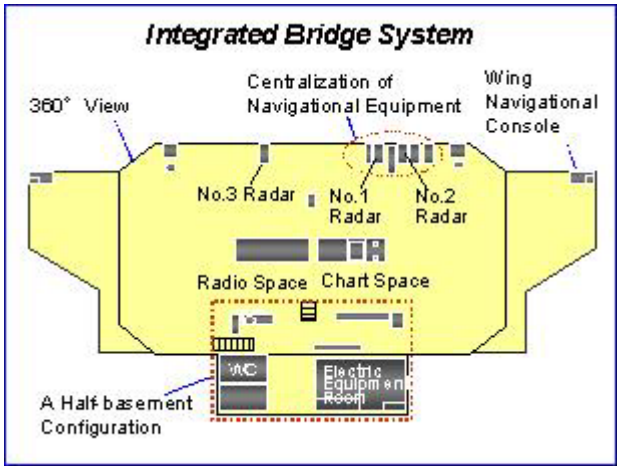


3.3 New clad steel by vacuum roll bonding with high frequency induction heating



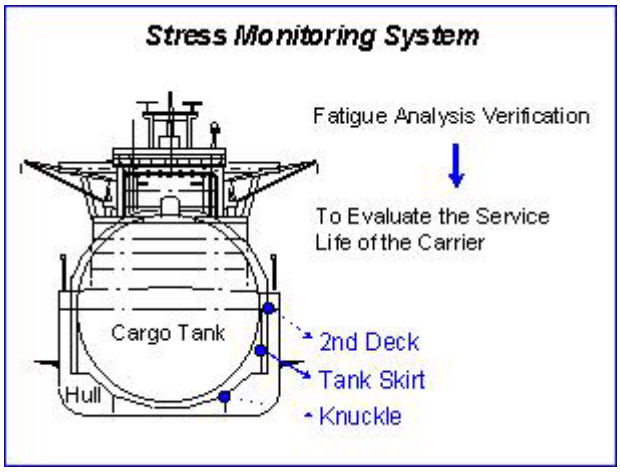
Stainless steel is used as a thermal brake between the cargo tank of aluminum alloy and the hull of steel. A dissimilar metal joint of aluminum and stainless steel called STJ is used in the tank skirt that retains the tank to the hull. Explosion-bonded clad steel made of aluminum, titanium, nickel and stainless steel has been used in the STJ for conventional LNG vessels. A new clad steel that bonds aluminum directly to stainless steel using a high- frequency heating vacuum roll process is being installed in the LNG Jamal. This method is aimed at preventing oxide film growth by applying a vacuum, as well as producing new boundary surfaces after destruction of the oxide films by drawing the material in the rolling process. The reliability of the joint is demonstrated in the LNG Jamal where being used on part of No.1 and No. 2 tanks. This technology would contribute to an reduction of high production cost as well as in the impact that explosion bonding has on the environment.

3.4 Integrated Bridge System(IBS)



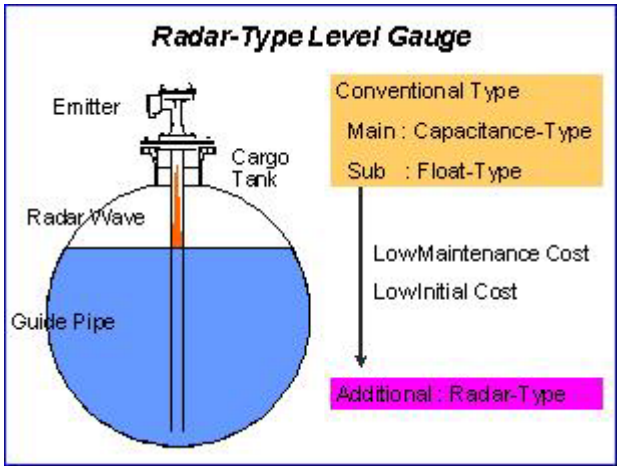
IBS is a navigation support system featuring the following points and was adopted to ensure safer navigation. Navigation information was centralized by integrating navigational equipment that is normally spread out in the bridge. The equipment in the bridge that would normally block the view out the rear of the bridge in the conventional onboard placement was installed lower in a half-basement configuration. This is the first LNG vessel bridge to offer a 360 degree view. Opinion of the transporter is fully considered in the design of LNG Jamal and we have received very positive and favorable response from the crew and pilots.

3.5 Hull stress monitoring system



This is the measurement system of acceleration and stress taken on the hull during its service and use hull motion data and stress measurements to verify external forces presumed in the design. The data we have taken shows that measured external forces on the hull are much lower than those which are presumed in the design, and we believe we could use LNG Jamal for much longer than her project life. We will continue to accumulate those data and this research will be used to extend the service life of the LNG vessels and reflect on the future design of our fleet.

3.6 Radar-type Level Gauge



Capacitance type and float type level gauges have been used in the cargo transfer system for LNG vessels. We went into prompt action to try to use this new radar-type level gauge system and LNG Jamal is experimentally equipped with it in one cargo tank. Both capacitance type and float type level gauges also installed on the LNG Jamal. A new radar type level gauge uses an emitter installed above the tank to send radar waves toward the LNG surface and the gauge calculates the distance to the LNG surface based on the time it takes for the waves reflected by the surface to return to the radar device. The new radar-type level gauges have shown an excellent maintainability and we have confirmed the agreement between the data collected by these gauges during our actual voyages and those measured by conventional types of level gauges. We believe that the test application of the radar-type level gauge on our LNG Jamal set a precedent for this type to become a mainstream of level gauges to be installed on LNG vessels.

The LNG Jamal incorporates various innovative technologies to reduce costs and improve safety in LNG transportation. These technologies have been verified in actual service and resulting data can be used to further improve the technologies to ensure that they will be put to maximum use in LNG transport for the 21st century. LNG Jamal will undergo the first dry dock in 2003, in which we will inspect the vessel, review the operational data and improve equipment and systems, wherever necessary. This will provide an opportunity for us to confirm her soundness and to achieve even greater flexibility and cost efficiency in operation. We are confident that the new technologies adopted by this ship will play a pioneer role in the development of new LNG carriers for the future. Osaka Gas International Transport fleet will continue to be committed to offering the highest level of reliability at the most competitive freight and thus meeting demanding needs of their clients.

Osaka Gas wishes to express its sincere appreciation to Osaka Gas International Transport Inc., NYK Line (Nippon Yusen Kabushiki Kaisha), Mitsubishi Heavy Industries, Ltd. and Chiyoda Corporation for rendering their expertise in the development, construction and operation of this vessel as well as sharing challenging spirit. It also expresses great thanks to the Oman LNG L.L.C. for their valuable cooperation in the LNG transportation.

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