STUDY ON THE OPTIMUM DESIGN PRESSURE OF IMO TYPE C LIQUEFIED HYDROGEN TANK CONSIDERING FRACTURE MECHANICS AND BOIL OFF GAS ACCUMULATION

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ABSTRACT

With the global environmental regulations, interest in hydrogen, one of the representative green energy sources, is increasing. In line with the trend, each government and company is starting to prepare for a hydrogen society, and the shipbuilding industry is preparing for the liquefied hydrogen carrier market. For cargo containment system which is one of the key elements of the development of liquefied hydrogen carrier, various types such as membrane and independent type A, B and C tanks defined in the IGC code are being investigated. In the case of small and medium-sized carriers currently under development, IMO type C tank is most likely to be applied, which is advantageous for improving thermal insulation performance through the application of a vacuum insulation system and minimizing cargo loss by accumulating boil-off gas during transportation. The minimum design pressure for type C tank is defined in IGC code to ensure that the dynamic stress is sufficiently low, so that an initial surface flaw will not propagate more than half the thickness of the shell during the lifetime of the tank. However, it is necessary to consider whether it is reasonable to apply the formula for determining the minimum design pressure to LH2 since LH2 has properties which are quite different from those of conventional cryogenic cargoes such as LNG or LPG. In this paper, the background of the formula in IGC code has reviewed, and the compatibility of those with the LH2 type C tank has carried out.

KEY WORDS: Liquefied hydrogen carrier; IMO type C tank; IGC code; Design pressure; Fracture mechanics; Boil-off gas; Vacuum insulation system.

INTRODUCTION

Hydrogen, one of the representative green energies, is classified into gray, blue and green hydrogen depending on the production method. Among them, green hydrogen is the least carbon-emitting hydrogen and is produced by electrolysis of water using electricity obtained through renewable energy such as wind and sunlight. Depending on the environment of each country, there is a difference in green hydrogen production capacity, which is expected to generate demand for the transportation of hydrogen energy between countries.

Transportation by ship is a conventional long-distance mass transport method, and the development of LH2 carriers is essential as preparation for a hydrogen society.

LH2 is a cargo with a vapor pressure exceeding 0.28MPa at 37.8℃. Hence, LH2 carrier should be designed to meet the requirements of the IMO IGC code. The IGC code defines various types of CCS, such as membrane and independent A, B, and C types. Determining the appropriate CCS type and it’s specifications considering the cargo characteristics is a very important issue in terms of safety and economic feasibility of LH2 carrier.

Characteristics of LH2

Table 1 shows the characteristics of LH2 compared to LNG, which is the lowest-temperature cargo currently transported by large commercial ship.

Table 1. Physical properties of LH2 compared to LNG

<table>
<thead>
<tr>
<th>Property</th>
<th>LH2</th>
<th>LNG</th>
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<tbody>
<tr>
<td>Temperature (at 1atm)</td>
<td>-253℃</td>
<td>-163℃</td>
</tr>
<tr>
<td>Density (at 1atm)</td>
<td>71 kg/m³</td>
<td>424 kg/m³</td>
</tr>
<tr>
<td>Latent Heat (at -253℃)</td>
<td>447 kJ/kg</td>
<td>510 kJ/kg</td>
</tr>
</tbody>
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Assuming an outside air temperature of 45℃, according to the conductive heat flux calculation formula of Eq. 1, LH2 has 1.43 times higher heat flow into the CCS from outside air than LNG with the same