Optimization of Procedures from Charge of Silica Hollow Microsphere to Vacuum Formation for Insulation System of Liquefied Hydrogen Storage Tanks

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ABSTRACT

High performance insulation system is needed for cryogenic liquefied gas fuel storage tanks. Especially, liquefied hydrogen (LH\textsubscript{2}) has boiling point of 20K (-253°C), which is much lower than other liquefied gas fuels such as ammonia and natural gas. When the LH\textsubscript{2} storage tanks are designed, highly advanced insulation system including vacuum space is no longer an option like it was for the other liquefied gas fuels. For the efficient carriage of LH\textsubscript{2}, a larger volume of cargo containment system with a higher vacuum level of insulation system should be developed continuously. There are many configurations developed for the vacuum insulation systems such as multi-layered insulation (MLI), vacuum insulation panel (VIP), particulate insulation or their combinations. It is very difficult to determine the optimized insulation system for the large-volume cargo containment system because each one shows different thermal conductivities depending on the degree of vacuum pressure and difficulties of the vacuum formation. With such difficulty in optimizing the insulation system, cost, constructability, and performance of thermal insulation also have to be considered simultaneously. In this study, a series of preliminary lab-scale experiments were carried out to obtain an understanding of constructability of insulation materials in the annular space during the vacuum forming process. As a result, this manuscript described the results of the insulation performance prediction of silica hollow microspheres and construction process simulation of the particulate vacuum insulation system charged with silica hollow microspheres.

KEY WORDS: Liquefied hydrogen (LH\textsubscript{2}), Storage tank, Vacuum insulation system, Liquefied gas carrier ship, Silica hollow microspheres, Constructability test

INTRODUCTION

Recently, so much global attention to the environmental pollution has been grown with many keywords such as global warming, decarbonization, and clean energy (renewable energy). Hydrogen is the most suitable solution for those keywords. Hydrogen as a means of storage and carrier could compensate many disadvantages of renewable energy resources. Production of renewable energy could be independent to region (fair productability to anywhere); however, the efficiency of the production is seriously dependent to the ambient environment whether it is day or night, sunny or rainy, and calm or windy. Thus, an energy storage system is necessary and very important regardless of its form whether it is an electricity in the batteries or certain materials like hydrogen gas because the surplus energy could be used later in the right man in the right place.

There is another important factor that has to be addressed before using such energy, the cost. As it is mentioned before, production cost of renewable energy which can be produced anywhere would be varied with different area depending on the amount of sunlight radiation and the status of installed facility. Energy demand would also be different to the countries. Because of such difference in production cost and energy demand in different countries energy trade (especially, between continents) will take place. Thus, they are the reasons that we have to develop the enlarged hydrogen gas carrier.

Here, why hydrogen? It is the most abundant resource in the universe, in various forms, and everywhere on the planet. On a mass basis, hydrogen has nearly three times the energy content of gasoline; 120 MJ/kg for hydrogen versus 42-44 MJ/kg for diesel and gasoline as shown in Figure 1. However, the volume has to be decreased since its density is very low.

Fig. 1 Comparison of volumetric and gravimetric energy density for several fuels (US Dept. of Energy)