ABSTRACT

In the Floating LNG (FLNG) development, STS (Ship-to-ship) offloading operation is considered to transfer LNG cargo into shuttle LNG carrier through loading arm system with side-by-side mooring arrangement. For the safe operation of loading arm, the good offloading operability regarding operation envelop is one of key factors in FLNG development. The operational envelop of loading arm is functions of relative motion and wave drift force between two vessels. Also, the STS offloading operability is affected by the side-by-side mooring configuration.

To ensure safe loading arm operation, the relative motion reduction methodology or device, and optimization of side-by-side mooring arrangement are required. Based on the relative motion reduction concept, we performed model test for the relative motion at loading arm point in two environment conditions. The experimental results show the present reduction concepts can be used effectively to ensure safe loading arm operation.

KEY WORDS: FLNG; STS; loading arm; relative motion.

INTRODUCTION

As the demand of natural gas is increasing, a LNG-related offshore plant such as FLNG and FSRU (Floating Storage and Re-Gasification Unit) is receiving much attention these days. In general, many offshore operations involve the use of two or more floating structures, which are positioned closely to transfer oil or gas during offloading operation. In case of the LNG-related offshore plant, a side-by-side offloading system with loading arm is applied instead of a typical tandem offloading system.

The side-by-side moored vessels show different characteristics from the tandem moored vessels. Hydrodynamic interaction between the vessels is highly increased and it gives an effect on relative motion and drift forces due to their close proximity (Kim and Ha, 2002, 2003, Ha and Kim, 2004). The shielding effect on current and wind load is another important consideration (Yuck et al. 2007). Recently, for more accurate results, the time-domain approach using Rankine panel method is applied to the multiple-body problem (Kim at al, 2009).

One of the most concerned phenomena on the development of FLNG is undesirable large relative motion response between FLNG and LNG carrier during offloading due to hydrodynamic interaction. The large motion and relative motion causes the damage of ship hull, offloading system and collision between FLNG and LNG carrier. Because of these serious problems during offloading operations due to the hydrodynamic interaction effect, it is very important to study the motion behaviors between two offshore floating structures, such as FLNG and LNG carrier in waves. (Kim and Ha, 2002, 2003, Ha and Kim, 2004)

For the loading arm operation during offloading operation, the operational envelop is one of operability criterions. Generally, the operational envelop is function of relative motion and wave drift forces between two floaters. To design the loading arm system in the basic design stage, the accurate results of relative motion and drift force between two floaters are required.

In this paper, the conceptual relative motion reduction methodology for the side-by-side moored FLNG and shuttle LNG carrier is introduced to enhance superior STS offloading operability. Through experimental study, it is found that the proposed motion reduction devices reduce the relative motion between two vessels significantly, and finally, offloading operability is much better than before.

SIDE-BY-SIDE OFFLOADING

Side-by-side offloading have several processes; approach/berthing, offloading, depart. Among the processes, offloading process takes more time to transfer the gas by using loading arm in the side-by-side mooring arrangement. Table 1 shows the typical side-by-side offloading process. The limitations of offloading process are mooring line, fender force and loading arms. Generally, side-by-side mooring lines and floating pneumatic fenders are used for the offloading operation of side-by-side moored vessels. The liquefied natural gas is transferred from the FLNG into the LNG carriers by means of loading arms on the FLNG. The tip of the loading arm is connected to the manifold of the LNG carriers.

For the safe STS offloading operation, the dynamic load acting on the mooring system has to be smaller than the maximum allowable load. Also, for the safe loading arm operation, the operational envelop is one