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Sloshing Load Assessments for a Midscale Single-Row FLNG

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The application of the single-row arrangement system into a midscale floating production unit of liquefied natural gas platform is introduced based on numerical and experimental studies on sloshing load. An increased lower chamfer height is applied to reduce sloshing impact load. Wave scatter diagrams and extreme sea states at North West Australia are considered. In addition, the wave height limitation in offloading operation is taken into account. A sloshing severity index is calculated and compared with sloshing model test results. Sloshing pressure distributions are derived from proposed computational fluid dynamics (CFD) analysis, and the results are compared with those of model tests.

INTRODUCTION

The world's first and largest floating production unit of liquefied natural gas (FLNG), Shell's *Prelude* FLNG (Fig. 1), was fabricated successfully at the shipyard of Samsung Heavy Industries (SHI) in Korea. Recently, because of low oil and gas prices, the pattern of demand has changed as companies explore projects with low capital expenditure (CAPEX). In this context, demand for small to midscale facilities, including FLNG and floating liquefaction storage and offloading vessels, is more increasing than that of large-scale facilities. At the same time, various efforts have been made to minimize CAPEX. One example is the application of a single-row tank arrangement, which can help reduce CAPEX since both the size of insulation areas and the number of pump towers can be decreased, and the center of bulkhead can be removed.

A cargo containment system of FLNG needs to be designed to be able to operate at all filling conditions. It is generally accepted that significant sloshing impact pressure can be imposed at intermediate filling levels (Pastoor et al., 2004; Zhao et al., 2004). Regarding the sloshing load assessment, a new methodology published by EM^{PACT}, which is based on a probabilistic-based framework, was suggested by Kuo (2009). Paik et al. (2014a) proposed a new method to determine the design sloshing load considering the various environmental scenarios for FLNG. Despite escalating costs, a double-row tank arrangement is applied for the purpose of minimizing potential risks resulted from considerable sloshing impact load under partial filling conditions (Park et al., 2009; Pek, 2011). In general, small and midclass floating LNG facilities aim to operate nearshore with relatively mild sea conditions. Under these circumstances, it is possible to apply a single-row tank arrangement as shown in Fig. 2. However, considering the size of cargo tanks and the sea conditions, there is a possibility of a high sloshing impact load with a single-row tank arrangement. In this sense, the sloshing impact load needs to be investigated carefully, and a safe cargo containment system should be provided.

In this paper, the application of a single-row arrangement system into a midscale FLNG is introduced based on numerical and experimental studies on sloshing load. To reduce the sloshing impact load, the concept of the SHI S-Tank is employed to a single-row tank. Wave scatter diagrams and extreme sea conditions in North West Australia, where the environment is relatively harsh, are considered in a sloshing model test as part of a conservative assessment of sloshing load. Moreover, wave height limitation in offloading operation is taken into account. The sloshing

Fig. 1 Shell *Prelude* FLNG

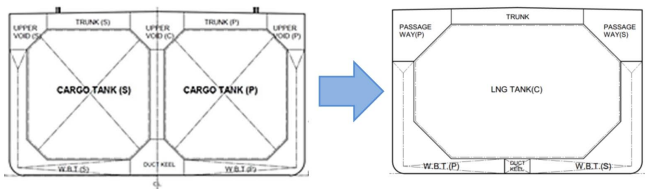

Fig. 2 Double-row arrangement (left) compared with single-row arrangement (right)

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