Sloshing Assessment of LNG Vessels for Unrestricted Tank Filling Operation

Jong Jin Park, Jang Hoon Seo, Chang Hun Jin, Ki Hun Joh, Byung Woo Kim and Yong Suk Suh
Samsung Heavy Industries Co., Ltd
Geoje, Gyeongsangnamdo, Korea

Yonghwan Kim
Seoul National University, Seoul, Korea

ABSTRACT

Conventional LNG vessels with membrane cargo containment system have tank filling restrictions between 10% and 70% based on tank heights. The main reason of barred filling range is due to the high sloshing pressures around these filling levels.

The present study is to find the practical solution for mitigating sloshing pressures and make it possible to operate without barred filling ranges. The proposed method is shape optimization of LNG tank to reduce sloshing pressures around restrict filling levels. The optimum tank shape is suggested in the present study. The numerical sloshing analysis and model test have been carried out to validate whether the suggested optimum tank shapes show the possibility of applying all filling operation. The developed optimum tank has also applied to the 160K LNG carrier to find the possibility of practical applicability.

KEY WORDS: Sloshing, LNG Vessel, Optimum Tank Shape, LNG Cargo Containment System.

INTRODUCTION

In general, LNG carriers with membrane cargo containment system have tank filling restrictions between 10% and 70% based on tank height. The main reason of filling level restriction is due to high sloshing pressures around 20% to 40% tank filling levels (ABS, 2009, LR, 2009, Lee at al., 2004, Macdonald, 2008, Pastoor at al., 2004 and Zhao et al., 2004). In the case of FLNG (Floating LNG) and LNG-SRV (LNG-Shuttle and Regassification Vessel), there is no way to avoid intermediate filling levels due to the production, offloading and regasification operations.

The simple and clear solution for making all filling operation is to increase the capacity of LNG cargo containment system or mitigate sloshing pressures.

For the LNG-SRV, the both wave height and heading are restricted during partial filling operations. In the case of the recent FLNG projects including SHELL Prelude FLNG, two-row tank arrangements are adopted to reduce the LNG tank breath, which can mitigate sloshing pressures around 30% tank filling levels. Both methods have been used for the practical solution to reduce sloshing pressures.

Several researches have been carried out to reduce sloshing loads by putting internal devices inside of cargo tanks (Anai et al., 2010 and Kim et al., 2012). These internal devices might be needed extra cost for construction and the safety of internal devices in LNG tank should be validated for the practical purpose. These methods have not used practically yet.

The present study is to suggest the efficient way for reducing sloshing pressures and find possibility of all filling operation. The proposed method is the shape optimization of LNG tank to reduce sloshing pressures. Several optimum LNG tank shapes are suggested. The numerical sloshing analysis has been carried out to find that the suggested optimum tanks show the possibility of all filling operation. Numerical sloshing analysis program called SHI-SLOSH (Ha et al., 2002 and Park et al., 2006) has been used for the present tank shape optimization calculations.

The developed optimum tank shape has also applied for 160K LNG carrier to assess the possibility of practical applicability. The sloshing model test also has been carried out to validate the possibility of all filling operation for the final shape of the optimum tank. The model test has been carried out in SNU (Seoul National University).

OPTIMIZATION OF LNG TANK SHAPE

Tank Shape Optimization for All Filling Operation

As seen in the Fig.1, conventional LNG vessels with membrane cargo containment system have tank filling restrictions between 10% and 70% based on tank heights (LR, 2012). It is well known that the sloshing pressures of conventional LNG carriers are very high around 30%