A Study on the Characteristics of Piezoelectric Sensor in Sloshing Experiment

H.I. Choi¹, Y.M. Choi¹, H.Y. Kim², S.H. Kwon², J.S. Park³, K.H. Lee⁴
¹ Dept. of Naval Architecture and Ocean Engineering, Pusan National University, Busan, Korea
² Deawoo Shipbuilding & Marine Engineering, Geoje, Korea
³ Dept. of Naval Architecture, Ocean, and IT Engineering, Kyungnam University, Masan, Korea
⁴ Advanced Ship Engineering Research Center, Pusan National University, Busan, Korea

ABSTRACT

This paper presents an experimental investigation of characteristics of piezoelectric sensor in sloshing experiment. The effects of thermal shock, diameter, and mal-mounting were investigated. The effect of AC and DC coupling was also investigated. The longitudinal as well as transverse model test results were investigated along with video clips captured with high speed camera for two different filling ratios.

KEY WORDS: Sloshing impact pressure; Piezoelectric sensor; AC coupling; DC coupling; Filtering; Hydrostatic pressure.

INTRODUCTION

The increase of consumption of LNG (Liquefied Natural Gas) accelerates the increase of the size of the LNGC. The traditional design criteria will not applicable to the design of new LNGC. When it comes to the sloshing load estimation, experimental verification is needed most of the time due to the complexity of the sloshing phenomenon. It means that accurate measurement of impact pressure can be one of very important topics. Much research has been done on piezoelectric sensors (Gautschi, 2002; ISA 1975; ISA 1982; Norton 1969, 1982). However, not much research on impact pressure has been reported. Therefore understanding the characteristics of the pressure sensors is essential in sloshing experiment (Choi, et al, 2009). To get to know better the characteristics of pressure sensors some tests have done. The effect of diameter was tested. Two sensors with diameters 9.5 mm and 5.5mm were tested. It turned out that both of the sensors give us quite identical impact pressures within the tested impact range. Thermal effect was investigated. The temperature difference between the sensors and water affected the magnitude of the impact pressures. It was observed that ICP type sensors are very sensitive to the thermal shock. However, it conclusion was made from the exaggerated temperature difference between them. Therefore this result should not be generalized. The effect of mal-mounting was investigated. The hollow and protruding mounting setup were tested along with flush mounting. It turned out that mal-mounting influenced the magnitude and type of the impact pressure time history. The wiggles and extra magnification of second peak were appeared. Lastly AC coupling and DC coupling effect was researched. The pressure measured with both coupling differs when the signals are static. However, when it comes to the impact pressure the magnitude of them are quite identical. The sloshing tests were done with longitudinal as well as transverse 1/50 scaled models of 138k LNGC. The impact pressure was analyzed with video clips captured with high speed camera. Two different filling ratios of 10%H and 20%H were tested. The close look at the pressure time history and video clips clearly showed the difference between them.

EXPERIMENTAL SETUP AND TEST

Two kinds of experiments have been carried out. The drop test was done to investigate pressure sensor characteristics. The test setup is shown in Fig. 1. The compressed air was released to simulate wet drop. This test facility showed excellent repeatability. The test items were the effect of diameter, the thermal effect of measured pressure sensors, the effect of mal-mounting, and the effect of AC, DC coupling.

![Fig. 1 View of installation of sensors on the specimen](image)

To take a close look at AC, DC coupling effect, 2-D MODEL tank test was also carried out. The experiment was done in motion platform at Pusan National University whose picture is shown in Fig. 2. This motion platform can simulate 6 degree of freedom. The model tanks are 1/25 scale longitudinal and transverse model of 138,000 m³ LNG carrier. The dimension of the models are shown in Table 1. Two kinds of pressure sensors were used. There two different features between them. The diameter of the sensors are 9.5 mm and 5.5 mm. The sensors whose diameter is 9.5 mm is piezoelectric sensors while the one with 5.5 mm diameter is ICP (Inner Circuit Piezoelectric) type. The location of the sensors are presented in Table 2 and Table 3. Table 4. shows the test matrices of the test. 20 % and 70 % filling ratios were tested. The