An Experimental Investigation of Hydrodynamic Impact on 2-D LNGC Models

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ABSTRACT

This paper presents an experimental investigation of hydrodynamic impact on two dimensional models. The models tested are 1/25 scale longitudinal and transverse models 138K LNGC tank. Only longitudinal mode of excitation was tested. The filling ratios tested was 20% and 70% of the tank height. The amplitudes of the excitation were 10% and 20% of the tank length. The measured data were analyzed. The time histories were of the pressure data were presented. The statistics of three maximum peaks were presented. They are maximum pressure, the average of one third highest pressures, and the average of one tenth highest pressures. The flow pattern was captured by high speed camera. The flow patterns at every quarter of the exciting period were presented.

KEY WORDS: Sloshing impact pressure; 2-D model tank; longitudinal model tank; transverse model tank. sloshing pressure time history

INTRODUCTION

The demand for natural gas is getting bigger and bigger. Natural gas supplied a quarter of the world energy consumption in 1999 according to statistics. Its consumption is expected to be increased from the environmental point of view. It is almost pollution free energy. As a result, the world fleet of LNG carriers has also increased accordingly. The efficiency of the transportation can be increased if designers come up with the idea of increased LNG tank size. This may, in turn, require technological advancement on several issues concerning draft limitations, increase of propulsion efficiency and maneuvering ability.

During the operation in the ocean, sloshing can be one of the very important issues due to its substantial impact on the tank wall and structures. The sloshing phenomenon has drawn much attention due to its practical as well as academic interests for a long time in various engineering and scientific fields. Many research topics can be stated about sloshing phenomenon itself. Not to mention the sloshing loads itself, the scale effect (Bass1974; Bass1985), compressibility effect (Bass,1972; Florschuetz,1965), hydro-elasticity effect (Kapsenberg, 2003; Lee, 1997), viscous effect (Bass1974) have to be investigated to get a good view on sloshing phenomenon. Excellent references for the general procedure for estimating sloshing load on LNGC tank with experiment can be found in Patour (2005) and Rognebakke (2005). The list on sloshing research topics may not be exhausted even with the above illustration. Due to the complexity of the sloshing phenomenon the experimental investigation is inevitable. This study presents the experimental results of sloshing test to investigate the impact pressure on sloshing load. To provide details about sloshing phenomenon pressure time history, statistics about peaks, and flow shapes are presented. The 1/25 scale models of 138K LNGC were tested. Only two dimensional aspects of the sloshing loads were investigated to simplify the analysis. Longitudinal and transverse models were tested to see the impact pressure. The two different filling ratios were tested. The pressure time histories are presented. The flow patterns of the sloshing phenomenon were captured by the video camera and presented. The impact pressure time history was recorded and analyzed. The pressure time history of the individual channel was compared for 2D-models.

EXPERIMENTAL SETUP

The sloshing test facility in Pusan National University has the ability to perform 6-degree of freedom motion. The facility is consisted of a machinery, motion control unit, and related software. The machinery unit is consisted of an actuator body, actuator bracket joints, upper and lower frame, and AC servo motor and driver. The actuator is an electric actuator. The motion control unit employs DSP algorithm to control the servo motor. The motion control unit is equipped with safety recovery function so that it can detect any unusual operation of the machine to stop the system in case of malfunctioning. The maximum capacity of 4 tons can be tested with this facility. The overall view of the facility and model setup are shown in Fig. 1. The total motor power to operate this facility reaches up to 90kW. The two different models tested are shown in Fig. 2. The principal dimension of the model is also shown in Fig. 2. The model was made of plexi-glass. The thickness of the model wall is 40mm. The total number of 8 pressure sensors was installed for the longitudinal model. Since the geometry of the transverse model is more complicated than that of longitudinal model 10 pressure sensors were attached. The specific locations of the sensors are tabulated in Table 1. The pressure sensors are Kistler made piezoelectric type sensors. The diameter of the sensor is 9.5mm. The sampling frequency in this experiment was 20 kHz. The National Instruments PXI-4472B, an extension of the NI 4472 family, was used for data acquisition purposes. The NI PXI-4472B provides 8-channel dynamic signal acquisition for the high-accuracy frequency-domain measurements. The eight input channels of the NI PXI-4472B simultaneously digitize input signals over a bandwidth from DC to 45 kHz. This NI PXI-4472B was used with the LabVIEW Sound and Vibration Toolset.

TEST CASE

The models of 138K LNGC model were tested for two filling ratios. They are 20% and 70% filling ratio of the tank height. Each test was lasted for 50 minutes. Only the translational motions were tested. The exciting frequency tested was natural frequency of the water depth. The motion amplitudes correspond to 10% and 20% of the length. The test condition is tabulated in Table 2. The natural frequency was