EVALUATION OF A MOVING DEVICE FOR SLOSHING SUPPRESSION BY USING MPS METHOD

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ABSTRACT

In the design of cargo tankers and FPSOs, violent loads due to sloshing may affect the vessel motion and its tank structure. Swash bulkheads and horizontal girders are some of the devices used to reduce the sloshing loads by changing the sloshing resonance frequency or adding damping to the flow. However, the efficiency of these fixed devices is limited to a small range of filling ratio. In order to develop a sloshing suppression system that works efficiently in a wider range of filling ratio, a moving sloshing suppression system is proposed in the present research.

There are analytical and numerical methods that can predict the sloshing motion and loads with restrictions such as simple geometries and low amplitude of the fluid motion. In order to overcome these restrictions, numerical simulations based on lagrangian particles are carried out. Unlike the methods based on meshes, the lagrangian particle methods have the advantage of calculating fluid motion with large displacement and fragmentation. Among the particle methods, SPH [1, 2] and Moving Particle Semi-implicit (MPS) [3] have shown promising results. In this work, a coupled numerical method was developed to predict the fluid loads and the motions of the sloshing suppression device. The fluid motion is evaluated by the MPS method and the obtained pressure is used to calculate the motion of the suppression device that is connected to the tank structure by springs (Figure 1).

As the parameter of study, lateral forces on the tank walls, free surface motion amplitude, motion of the suppression device and forces on the connection lines are used.
Figure 2 – Lateral force amplitude and lines forces.

One of the main concerns of the proposed sloshing suppression device is the force on the lines. Figure 2 shows the amplitude of the lateral force on the tank and lines as functions of filling level. The amplitudes are nondimensionalized by the fluid mass force amplitude considering it as a solid. The magnitude of the force on the lines is very small when compared with the lateral force on the wall and the reduction of the lateral force achieved by the suppression device. This is because while no suppression device is used, large sloshing loads occurs due to impulsive loads concentrated at a relatively short interval.

On the other hands, as the forces are concentrated at the lines, it is easier to reinforce the structures that support the lines to resist the sloshing loads when compared to the sloshing impact at the ceiling or lateral walls of the tank.

The moving sloshing suppression system presented a good attenuation of the free surface motion. The device is effective for the low filling ratios by reducing remarkably the sloshing force. It is also effective in the high filling ratios, by reducing the risk of sloshing impact on the tank ceiling. However, there are still other aspects that must be analyzed to conclude if the device is really applicable from the structural and economical point of view.

References