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Numerical simulation of performance of TLD device with a ribbed baffle

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Abstract

- The combination between tuned liquid damper(TLD) and elastic components has become a research hotspot.
- A TLD structure with a ribbed baffle is proposed in this paper.
- The partitioned solution of fluid-structure interaction method is used to numerically simulate the horizontal vibration attenuation process of five TLD devices.
- The superiority of the vibration damping effect of the structure with ribbed baffle is proved by comparing the vorticity contour

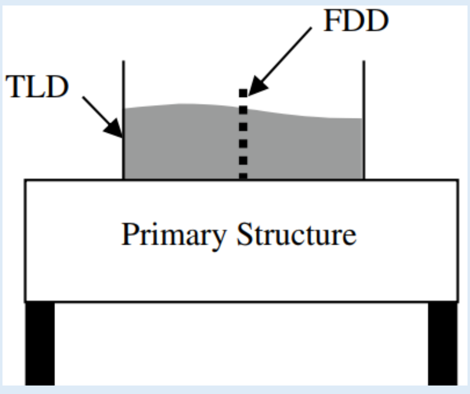
Introduction

The principle of TLD vibration reduction

In the process of liquid forced sloshing, the pressure difference, wave breakage and liquid viscous dissipation caused by sloshing liquid and wave are used to absorb and consume the vibration energy of the main structure and achieve the purpose of vibration reduction.

The combination between TLD and elastic components

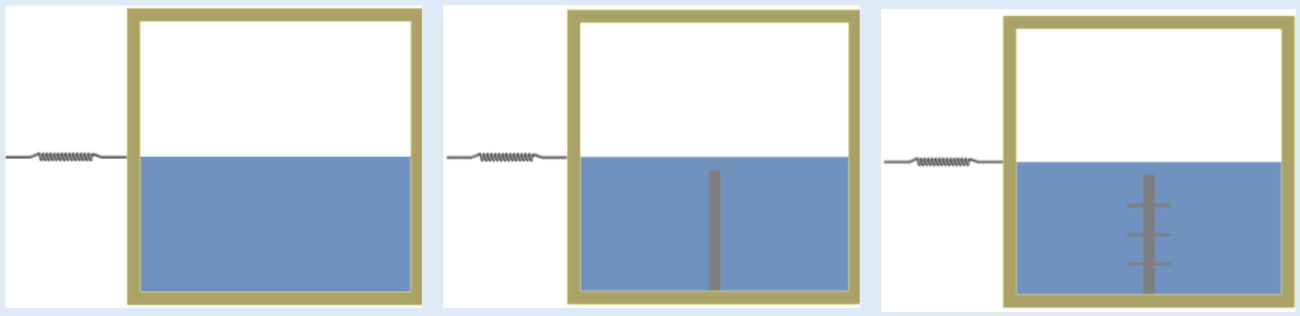
The good performance of interaction effect between violent shaking of liquid and large deformation of elastic material can strengthen the energy consumption capacity of liquid and the energy absorption capacity of elastic device.



Physical model and numerical method

Physical model

Device diagram of original structure, structure with baffle, structure with ribbed baffle



The physical model is a structural steel cube with four outer walls and exposed front and back. The inner cavity size is 100 mm ×100 mm × 100 mm, and the wall thickness is 5 mm, the volume is 210 cm^3 and the steel density is 7850 kg/m^3. The inner cavity is filled with water with a height of 50 mm; One end of the spring is connected to the fixed point, and the other end is connected to center of the container wall, and the spring with a stiffness of 6508 N/M is compressed for 5mm to give the structure an initial vibration. In order to ensure the high strength interaction between elastic materials and the swinging liquid, this case chooses the high elastic material with young's modulus of 6×10^6 Pa, density of 1100 $kg/m^3$and Poisson's ratio of 0.4, whose trademark is AXSONRE11820-(9).

Numerical method

The fluid mass conservation equation and momentum conservation equation

$$\nabla \cdot u = 0 \qquad \rho\frac{D\mathbf{u}}{Dt} = -\nabla p + \mu\Delta\mathbf{u} + \rho\mathbf{f}$$

The conservation equation of solid domain

$$\rho_s \ddot{d} = \nabla \cdot \sigma_s + f_s$$

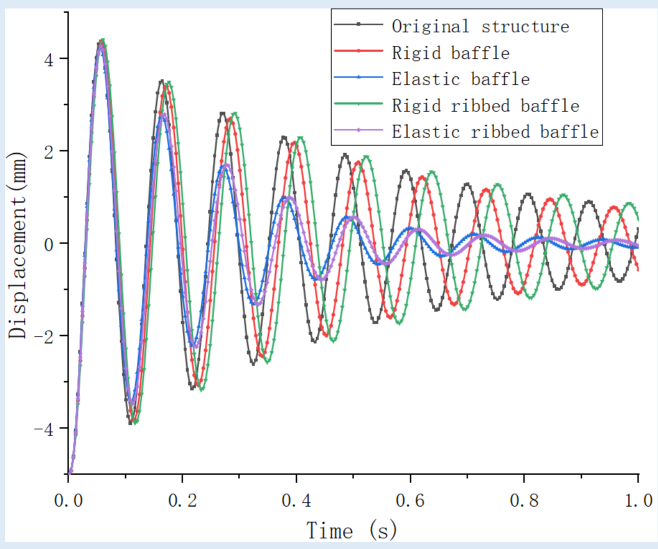
Where, is the solid density, is the local acceleration vector in the solid domain, is the Cauchy's stress tensor and is the solid volume force vector.

The fluid structure coupling equation

$$\begin{cases} \tau_f = \tau_s \\ d_f = d_s \end{cases}$$

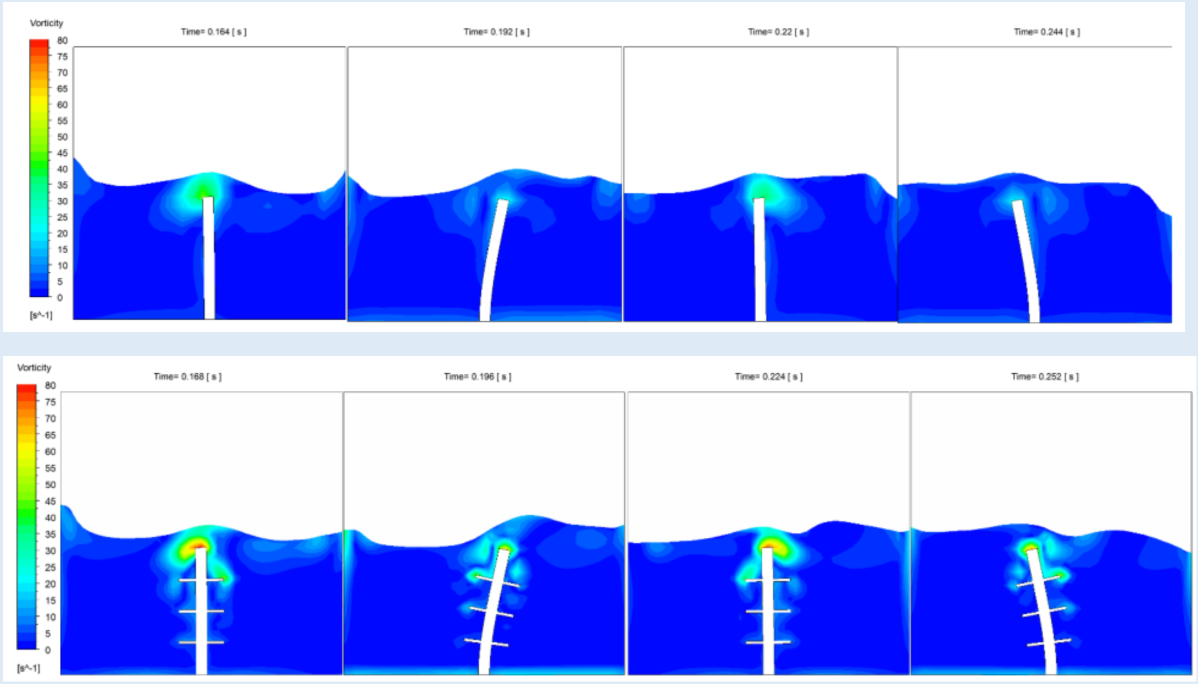
Result

Vibration reduction horizontal displacement of five TLD devices



The built-in baffle can prolong the vibration period of the TLD devices, slow down the frequency, and improve the vibration reduction effect. This is because the baffle can block the motion of the liquid, making the liquid sloshing more intense, and greatly enhance the interaction of fluid and solid. The built-in elastic ribbed baffle structure has the best damping effect.

Contour of 4 typical moments of structure with elastic baffle and structure with elastic ribbed baffle



It can be observed that the places with large fluid vorticity are concentrated near the free surface, the top of the baffle and the top of the fins. Because the flexible baffle has a larger interaction area with the fluid, and the interaction between the fluid and the solid is stronger, this explains the reason why the elastic baffle with fins has better vibration reduction effect than the elastic baffle without fins.

Conclusion

- ***The damping effect of the structure with elastic materials is obviously better than the structure with rigid materials*, and the damping effect of the structure with elastic ribbed baffle is the best. However, the frequency reduction effect of the structure with rigid materials is better. Under the condition that the frequency reduction requirements are high and the vibration reduction time is not high, it may be more appropriate to select the structure with rigid ribbed baffle.**
- ***The damping effect of the baffle with elastic fins is the best.* The following are the reasons:(1) the interaction area between the baffle with fins and the fluid is larger, and the area of pressure drop is larger. When the fluid structure coupling effect is strong, it is beneficial to damping. (2) The fin intensifies the disturbance at the top of the fin, intensifies the fluid shear and vortex near the top, and accelerates the energy dissipation.**
- **Besides, there are many kinds of elastic materials, and the selection of more appropriate elastic materials can further enhance the vibration reduction effect. Therefore, *it is necessary to pay attention to the latest development of elastic materials.***