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# NUMERICAL SIMULATION OF SLOSHING IN MULTI-BAFFLED CONTAINERS

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## ABSTRACT

The multi-domain boundary element method is developed in this work for numerical simulation of liquid sloshing in reservoirs and fuel tanks with baffles. The compound shell was a simplified model of a fuel tank. The liquid is supposed to be an ideal and incompressible one and its flow introduced by the vibrations of a shell is irrotational. The liquid vibrations in rigid and elastic tanks with baffles of different sizes and positions in the tank are considered.

***Keywords:*** fluid-structure interaction, liquid sloshing, boundary element method, baffle.

## INTRODUCTION

Sloshing is the low frequency oscillations of the free surface of a liquid in partially filled reservoirs. The dynamic response of structures containing the liquid can be significantly influenced by these oscillations, and interaction with sloshing liquid may lead to instabilities and dynamic failure. Usually liquid storage tanks are filled with oil, flammable or toxic liquids. Destruction of these tanks by seismic or shock waves from a nearby explosion can lead to environmental catastrophe. Although baffles are commonly used as the effective means of suppressing the sloshing magnitudes, the only few studies have assessed the role of baffle parameters (Guorong, 2009) and elasticity effects (Ravnik, 2016).

Most of the researchers have described the fluid-structure interaction in baffled tanks neglecting gravity or elasticity effects. Vibrations of the 2D elastic vessel partially filled with an incompressible fluid under the gravity force were considered (Bermudez, 1999), but the only 2D rectangular tank was under consideration. The important research (Gavrilyuk, 2006) was devoted to the vibration analysis of baffled cylindrical shells, but both shells and baffles were rigid.

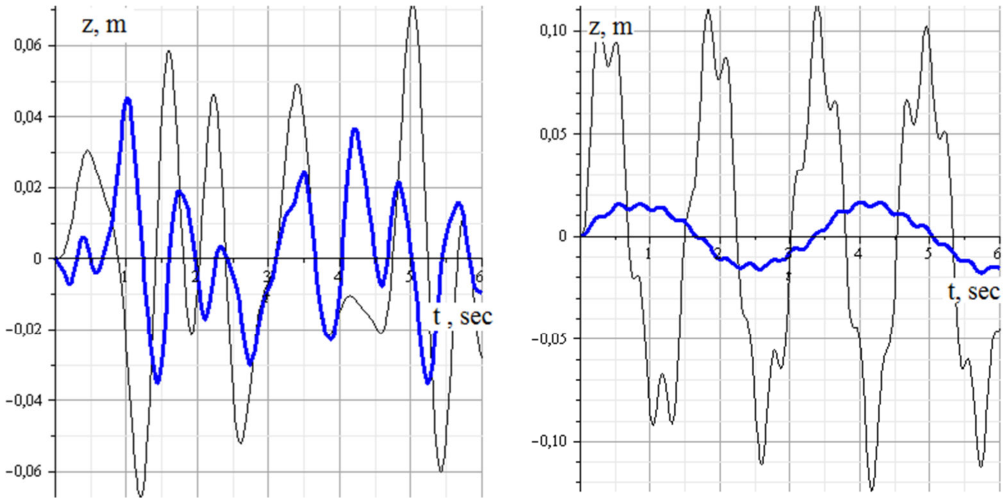
## RESULTS AND CONCLUSIONS

The elastic cylindrical tank with a flat bottom is considered, with radius $R = 1$ m, thikness $h = 0.01$ m, length $L = 2$ m, Young's modulus $E = 2\cdot10^5$ MPa, Poisson's ratio $\nu = 0.3$. The material's density is $\rho_s = 7800$ kg/m$^3$, the fluid density is $\rho_l = 1000$ kg/m$^3$, the filling level is $H$=0.8 m. In table 1 the frequencies of axisymmetric vivrations are presented. The baffle position here is $H_1$=0.45m, the baffle radius $R_b$ was variable. The value $R_b$=0 corresponds to the unbaffled tank. Fig. 1 a,b) demonstrate the time history of the free surface elevation $z$ in different points under harmonic excitation in the lateral direction. Fig. 1 a} and 1b) correspond to points of free surface with radiuses $r$=0.2 and $r$=0.8 respectively.

Table 1 - Frequencies of elastic cylindrical shells with baffles, *Hz*

| ***n*** | **Empty elastic shell** | | | | **Fluid-filled elastic shell** | | | |
|---|---|---|---|---|---|---|---|---|
| $R_b$ | 0 | 0.2 | 0.5 | 0.8 | 0 | 0.2 | 0.5 | 0.8 |
| **1** | 23.233 | 23.23 | 23.23 | 23.23 | 7.925 | 7.590 | 5.521 | 1.787 |
| **2** | 91.101 | 91.10 | 40.48 | 24.41 | 43.35 | 42.35 | 15.17 | 9.793 |
| **3** | 205.25 | 192.1 | 91.10 | 91.10 | 117.0 | 116.0 | 46.76 | 45.91 |
| **4** | 365.79 | 205.2 | 205.2 | 100.7 | 230.3 | 228.9 | 119.1 | 52.90 |
| **5** | 392.78 | 365.7 | 214.2 | 205.2 | 392.7 | 229.1 | 168.0 | 119.7 |

From these results one can concluded that both elasticity effects and the size of baffles are affect essentially on the values of natural frequencies




a) b)

Fig. 1 - Time history of the free surface elevation in tanks with (blue) and without baffle (black)

In practice, the effect of baffles usually can be seen after the baffle has been installed. The proposed method makes it possible to determine a suitable place with a proper height for installation of the baffles in tanks by using numerical simulation.

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