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ЗМІСТ

MODELING AND STABILITY ASSESSMENT OF SLOSHING IN HORIZONTALLY AND VERTICALLY PARTITIONED TANKS

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This study presents the development and application of advanced numerical approaches for analyzing the stability of fluid motion in tanks equipped with partitions of various configurations. The stability of sloshing in horizontally and vertically partitioned tanks is a problem of considerable theoretical significance and practical relevance, particularly for aerospace, marine, and terrestrial liquid storage systems. The presence of partitions substantially modifies sloshing dynamics by altering the free-surface frequency spectrum, reorganizing vortex structures, localizing energy, and shifting the onset of resonance. Neglecting these effects can lead to underestimation of dynamic loads, compromise structural safety, and reduce overall system reliability.

Experimental investigation of such processes, while informative, is often prohibitively costly, technically demanding, and in many cases hazardous. Large-scale facilities, sophisticated instrumentation, and rigorous safety protocols are required to reproduce relevant operating conditions. By contrast, computational modeling offers a safe, flexible, and cost-effective framework for examining a wide range of physical regimes and partition configurations.

The aim of the study is to develop a computational methodology for incorporating damping effects into the stability analysis of fluid motion in confined domains (such as reservoirs and fuel tanks) subjected to periodic external excitations. Particular attention is given to the influence of internal baffles, which act as additional elements for vibration attenuation [1].

The investigation considers rigid shells of revolution, partially filled with liquid, that are equipped with either horizontal or vertical partitions. In he present work, potential theory and singular integral equations are integrated with the boundary element method, the subdomain method, and the method of prescribed normal forms [2]. This hybrid approach enables accurate representation of both unpartitioned and partitioned geometries subjected to horizontal and vertical excitations. Stability boundaries are mapped through the Ains–Strett diagram, which provides a clear visualization of transitions from stable to unstable sloshing regimes [3]. The role of damping is examined using the Rayleigh matrix, leading to quantitative estimates of amplitude attenuation and shifts in the critical stability thresholds [4].The results demonstrate that the introduction of horizontal and vertical partitions has a profound influence on the stability characteristics of fluid motion. The Ains–Strett diagram effectively captures the sensitivity of the system to excitation parameters, while Rayleigh damping analysis confirms its capacity to suppress oscillations and extend the regions of stability. Taken together, these findings highlight the importance of partitions as a design tool for enhancing the safety and operational reliability of tanks in aerospace vehicles, marine vessels, and stationary energy-storage applications [4].

This study developed a computational framework for modeling free-surface disturbances in fluid containers subjected to horizontal and vertical external excitations. To account for uncertainties in load parameters and initial conditions, fuzzy logic was incorporated into the analysis. The role of Rayleigh damping was examined in depth, demonstrating its significant influence on the system's dynamic response. By employing the α-cut method for fuzzy load parameters and initial conditions, the study produced interval-based predictions that capture the spectrum of possible system behaviors under uncertainty, thereby improving the robustness and reliability of the proposed model. Future extensions of this work will address the incorporation of additional damping mechanisms, including baffles, floating covers, and other structural devices designed to mitigate fluid oscillations. Moreover, the analysis will be broadened to account for capillary effects, which play a critical role in shaping free-surface dynamics at small scales. Particular attention will be devoted to low-gravity environments, where the interplay between capillarity and reduced gravitational forces leads to fluid behaviors markedly different from those observed under terrestrial conditions. These investigations are expected to further enhance the predictive capability and practical applicability of the proposed modeling framework in aerospace, marine, and energy engineering contexts.

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