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PROF. DR. MARIAM JIKIA

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COUPLED BOUNDARY AND FINITE ELEMENT METHOD FOR STABILITY ANALYSIS OF LAUNCH VEHICLE

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ABSTRACT

For several decades, the problem of launch vehicle flight stability has been at the centre of attention of scientists, designers, and engineers [1,2]. New designs require additional research. This is due to an increase in the size of launch vehicles, new forms of fuel and oxidizer tanks, and an improvement in their internal structure [3]. To dampen unwanted vibrations, various kinds of dampers are used, such as internal vertical and horizontal partitions, floating covers, etc. [4,5]. Improved materials are also used to ensure strength and reliability [6].

This paper proposes a method for calculating filler oscillations in fuel tanks based on the application of boundary and finite element methods. Although modern computers of a new generation are capable of solving problems of large dimensions, it is still necessary to create refined modifications of known methods with increased speed for continuous monitoring of the state of tanks during the mission.

The methods of potential theory were applied in the research, which made it possible to reduce three-dimensional problems to the solution of surface singular integral equations [7]. We started with a thorough analysis of the resulting singular integrals and establishing the type of their singularities [8,9]. After developing an effective method for solving the resolving system of singular integral equations, the natural frequencies of fuel tanks were determined. Further, forced oscillations of partially filled tanks were considered. The cases of stability loss are studied, when the amplitude of oscillations of the liquid free surface sharply increases. This phenomenon occurs when the driving force frequencies coincide with the frequencies of natural oscillations. Also very topical is the case of parametric resonance, which is typical for tank oscillations under the action of a vertical force with a frequency that is a multiple of the lowest natural one.

Keywords: fuel tanks, sloshing, stability, boundary and finite element methods, singular integrals