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A MULTIVARIATE STUDY OF THE STABILITY OF TOROIDAL THIN-WALLED STRUCTURES CONTAINING LIQUID

Abstract

This study aimed to analyze the stability of toroidal thin-walled structure partially filled with liquid under the multi-factor loads. In this paper, toroidal shells, earlier used as fuel tanks for rockets, subjected to static loads e.g. hydrostatic pressure of liquid, pressurization of fuel tanks and atmospheric pressure. It is assumed that uniform cross section of toroidal thin-walled structure has two semicircle ends and a height. A thickness, internal pressure and liquid level of structure are the independent variables, each of which influences the natural frequency and the stability of structure. The stability assessment method of thin-walled axisymmetric structures containing liquid is proposed under combined conditions of static and kinematic factors. The problem of assessing the load capacity of structure in relation to each of specified factors separately, provided that remaining components of static load are unchanged, cannot be solved by standard methods for stability analysis based on the Euler theory of continuous equilibrium equations. The Euler's approach is based on simplification of problem to solve eigenvalue for multiplier that immediately scales all applied loads on the structure. Considering the eigenvalue problem of a pre-loaded structure, it is possible to investigate the behavior of natural frequencies by varying one of the constituent static load components with fixed others. Approaching the natural frequency to zero in the investigated range of values of the selected factor means reaching the boundary of the instability region. Thus, this makes it possible to assess the stability of structure on any constituent load component with fixed other values. Using variables as axises, the correlations of values are shown on three-dimensional graph and the surface on this graph separates the boundary of stability area. To calculate the natural frequencies of statically loaded axisymmetric thin-walled structure with liquid (and in a particular case without liquid), a template file has been developed on Visual Basic for Applications (VBA) system in Excel spreadsheet processor. The open code of the template blocks allows to automate the research process without special efforts to evaluate stability regions under multifactor static loading of the structure.