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DETERMINING THE BREAKING LOAD OF SMOOTH SPHERICAL AND CONICAL TANKS USING THE METHOD OF COMPUTATIONAL EXPERIMENTS

Abstract

The question of reducing the cost of ground development tests is of great importance today, including the cost of the tests to determine the actual safety margin for rupture tests. For solving this problem, it is necessary to develop a computer simulation procedure that allows determining the bearing capacity of launch vehicle structural components. In general, the algorithm of solving this problem consists of the following: Determination of the stress-strain behavior; Registration of test results. For strength computations, the finite element method is widely used along with the ANSYS and NASTRAN software that is based on the finite element method. For making computations, this software requires an adequate finite element model. The propellant compartment is one of the most essential components of an integrated launch vehicle. Let us discuss the solution to the mentioned problem for a combined propellant compartment. The stress-strain behavior of a propellant compartment was determined for the design case of loads on the propellant compartment during static tests. The combined propellant compartment comprises an oxidizer tank, a fuel tank, and an instrument compartment. The oxidizer tank is smooth, comprising a cylindrical section and spherical heads. The oxidizer tank is embedded in the fuel tank. The fuel tank consists of smooth conical shells. The instrument compartment is a stringer structure. This paper describes the stress-strain behavior computations for the following propellant compartment configurations: propellant compartment with the minimum thickness and stress-strain properties of materials as used in the design phase; propellant compartment with the minimum thickness and the actual stress-strain properties of materials as obtained from test results; propellant compartment with the actual stress-strain properties of materials and the actual thickness of the oxidizer tank upper head. The values obtained through computations were compared with the corresponding experimental data (loads, displacement, deformation). The computations were done using the finite element method and the MSC.NASTRAN finite-element computational software. The inner positive pressure is the determinative load parameter for the tanks of a combined propellant compartment. The inner positive pressure was applied to the oxidizer and fuel tanks, taking account of the water columns due to the water pressure (design case of loads during static tests). The geometric and physical nonlinearities were taken into account in the determination of the stress-strain behavior. The comparative analysis of computed and experimental data has demonstrated a satisfactory reproducibility of results. The best reproducibility of strength computation results has been obtained for the computational model of the propellant compartment with the actual stress-strain behavior of materials. The inner positive pressure was applied several times to the tested tank during the ground development tests, so it is planned to make a computation of propellant compartment structure for the actual stress history.