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Impact-Induced Mission Effects and Risk Assessments (3)

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MODELING OF DEBRIS PARTICLES IMPACT ON SPACE STRUCTURES

Abstract

The results of high velocity fragment or bullet interaction with thick metallic structures and thin walled fluid-filled containments. The closed form solution formulas for determining crater depth, radius and ejected mass being functions of impactor mass, speed and material of both impactor and target is provided. The dynamics of impactor deceleration after wall perforation of the fluid filled containment was studied being the function of the depth of perforation under the water level in case the containment was partially filled with water and partially with gas having a distinct fluid-gas interface. The developed models verified with results of experiments. The obtained solutions are applicable for evaluation of the consequences of high velocity impact on different ground based and space structures and developing concepts for effective shields design. This model allows to derive new formulas for calculation of depth of the punch, sizes of the crater and ejected mass being functions of the impactor mass, its velocity and material of both impactor and target. A new dimensionless criterion is introduced which characterizes different scenarios of the high-speed collision. It was shown that relatively small velocities (Snn¡¡1) bring to creation of the punch type crater, the depth of which linearly depends on the speed of the interaction. If critical value of the speed (Snn=1) is reached the impactor begins to deform irreversibly, which leads to increase of its cross-section and, as a consequence, decrease of the penetration depth. Thus there is certain range of interaction speed (1¡Snn¡5) where the enlarged velocity provokes decrease of the crater depth. Further speed increase makes the crater depth grow again as a square root of impact velocity. Mathematical model for the fragment impacting a rather thin-walled containment, which could be filled in with gas, liquid, or both liquid and gas phases having a distinct phase interface was developed. Ground-based experimental investigations were performed. It was demonstrated that on slowing down the fragment conversion of its kinetic energy into the internal energy of the surrounding gas (or fluid) takes place. The rapid increase of the density of energy in a small volume inside the containment gives birth to diverging blast waves inside the containment that reflects from the walls thus producing non-uniform loading. The present investigation was supported by Russian Science Foundation (RSF project code 18-11-00225)