NUMERICAL MODELING OF EROSION OF SURFACE OF 3D-PRINTED METAL PARTS UNDER MICROMETEROIDS IMPACT*

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Prediction of erosion rates is important for spacecraft life cycle planning and mission planning. The main mechanism causing erosion of the surfaces of space technology is exposure to micrometeorites. Due to the development of additive manufacturing of space technology elements in general, and 3D printing of metal parts in particular, it is necessary to develop models of material behavior under the influence of such meteoroids, taking into account the peculiarities of additive manufacturing. Characteristic features [1] of the thermal cycle of metal additive manufacturing are: (1) fast heating due to high energy density of beam source; (2) fast crystallization with high cooling rate due to the small volume of the melt pool; and (3) melt-back, including simultaneous melting of the top layer of powder and remelting of the underlying previously crystallized layers. Residual stress caused by the unique thermal cycle in AM of metal parts, and high residual stress gradients cause deformation of the parts, which dramatically impairs the functionality and properties of the final parts [2,3].

In this paper a numerical model of impact loading of material produced by the method of electron-beam fusion of powders is proposed. The model is based on the smoothed particle hydrodinamics method [4,5]. Special attention is paid to heterogeneity of distribution of mechanical properties of the material at the microlevel. It is known that the selective fusion of metallic powders produces an inhomogeneous residual stresses. At the same time multiple areas with increased microhardness (quenched areas) are formed. Two models of spatial distribution of such areas are considered in this paper: a probabilistic approach [6] and a pattern according to scanning strategy. The probabilistic model uses probabilistic law proposed in [6] and Perlin noise [7]. The influence of track width, degree of hardness variation and parameters of probabilistic distributions on mass histograms of fragments after impact and parameters of resulting craters is considered. Comparison results with impact experiments at speeds up to 3 km/s are given.

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