Role of vortex-like motion in contact loading of strengthening coating. Movable cellular automaton modeling

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ABSTRACT

Movable cellular automata (MCA) is an efficient numerical method in particle mechanics, which assumes that any material is composed of a certain amount of elementary objects interacting among each other according to many-particle forces. MCA makes feasible simulation of solid body behavior at different scales, including viscoelastic and plastic deformation, fragmentation and further interaction of fragments as granular material. In this paper MCA method is applied to modeling deformation of 3D coating-substrate system under its contact loading by rigid indenter. Main attention of the research is focused on the role of vortex-like structures in the velocity fields in elastic and non-elastic deformation of the strengthening coating and substrate.

The mechanical properties of model coating correspond to multifunctional bioactive nanostructured film (TiCCaPON) and the properties of substrate, to nanostructured titanium. Loading is performed by hard conical indenter with various ratio of normal and tangential components. The peculiarities of velocity vortex formation and propagation, as well as interaction with structural elements are studied.

One of application of the study is non-destructive technique for detecting nanoscale defects in surface layer of a material using frequency analysis of the force resisting to sliding of a small counter-body on the material surface, known as tribospectroscopy. Possibilities of this technique are studied based on 3D modeling by MCA method for the above mentioned coating with nano-pores of different geometries. It is shown that specific peaks at the friction force spectrum correspond to different geometrical characteristics of the nano-pores.