NUMERICAL SIMULATION OF THE INTERACTION OF A SLIDING SHOCK WAVE WITH A LAYER OF PARTICLES USING CARTESIAN GRID METHOD

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Abstract: The paper presents the results of direct numerical simulation of the problem of interaction of a sliding shock wave (SW) with a layer of moving and interacting particles on the impermeable surface. The mathematical model is based on two-dimensional Euler equations, which are solved in a region with variable boundaries using the Cartesian grid method. When describing the motion of cylindrical particles, the forces and moments of the gas pressure forces, as well as the contact forces arising from the interaction of particles, are taken into account. The stereomechanical impact theory is used to describe particle collisions. The formulation of the problem is close to that considered by Kosinski and Hoffmann (2005). In direct modeling, the effects of particles layer surface downward movement behind the SW, deformation of the front of the incident SW, as well as its refraction and re-reflections in the layer, and particles lifting are obtained. Dynamics of change of angular velocity of particle rotation in a quantitative expression is obtained that can be used for the analysis of the influence of Magnus force on the process of particles lifting behind the sliding SW.

Keywords: numerical simulation; shock wave; particles layer; Euler equations; Cartesian grid method; collisions; angular velocity

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Figure Captions

Figure 1 The schematic of the problem and a rule of bodies numeration

Figure 2 Simulation of the SW – moving cylinders interaction and Mach number isolines at time instant 48 μs: (*a*) simulation of the present authors, elastic interaction; (*b*) elastic interaction of particles from [16]; and (*c*) viscoelastic interaction of particles from [16]

Figure 3 Dynamics of SW – particles layer interaction: (*a*) predicted gas pressure distribution at time instant 12 μs; and (*b*) the schematic of major flow field structures

Figure 4 Flow around particles in the upper rows of the layer. Pressure distribution at time instant 12 μs and several instantaneous streamlines

Figure 5 Predicted pressure distribution at time instant 84 μs. Solid horizontal line corresponds to the initial upper boundary of the layer

Figure 6 Trajectories of particles from the second row (from the top) in the initial arrangement of particles in the layer

Figure 7 Angular velocities of particles 33 and 34

Figure 8 Qualitative comparison of particles distribution in the simulation of Ref. [10] (time instant 100 μs) (*a*) and in the simulation of the present authors (time instant 20 μs) (*b*)

Table Caption

Vertical velocities of cylinders lifted above the initial upper boundary of the layer at time instant 84 μs

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