THEORETICAL AND EXPERIMENTAL STUDY OF THE CHELYABINSK METEORITE DESTRUCTION UNDER COMPLEX LOADING.

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Introduction: Currently, potential source of the meteorites are near-Earth asteroids families – Apollons, Atons, etc. Theirs debris regularly cross the Earth's orbit and once in a hundred years occurs a significant event, such as fall of meteorite Chelyabinsk, LL5 ordinary chondrite, in February 2013 [1]. The risk of large fragments falls on the Earth makes detailed study of their strength and rate of decay under the complex multistage loading, very actual. In addition, near-Earth asteroids are primary targets for robotic and manned missions for scientific and exploration purposes that require mechanical strength data.

Stone meteorites usually are impact breccias of the surface layers of parent bodies. In ordinary chondrites there are two main petrologic components, which differed in genesis. This is the original chondrite material (A) composed of chondrules and minerals grains, and impact melts (B). Chondrite Chelyabinsk is coarse-grained impact melt breccias, where the A and B components occur in macroscopic values available for direct experimental study. To identify the possible mechanisms of meteoroids failure, we experimentally inverstigated the strength properties of the main components of Chelyabinsk meteorite using 3-axial loading [2].

Methods: To assess the spatial stress on the meteorite when it entering it into the Earth's stratosphere, we have to use observational data [3]. The fireball was first recorded at 97 km altitude, moving at 19.16 ± 0.15 km/s and entry angle 18.3 ± 0.2° with respect to the horizon. Combined entry mass of 1.3 × 107 kg (with a factor of two uncertainties) and a diameter of 19.8 ± 4.6 m is derived, assuming a spherical shape and the meteorite derived density of 3.3 g/cm3. Size and speed suggest that a shockwave first developed at 90 km. Observations show that dust formation and fragmentation started around 83 km and accelerated at 54 km. Peak radiation occurred at an altitude of 29.7 ± 0.7 km, at which time radar sensors measured a meteoroid speed of 18.6 km/s. At this rate, even the rarefied air of the mesosphere (0.01-0.02 g/cm3) behaves like a dense medium and hydrodynamic modeling is justified.

Resuluts: Numerical simulation by hydro dynamical module CFX ANSYS show that, during the early stage of the meteorite entry in the Earth's atmosphere, a very non-uniform pressure on its surface was occurred (see Fig.1). The maximum load occurs on the frontal part by squeezing the body and quickly decreases with distance from this point. This feature allows us to correctly assess the conditions of main cracks appearance and propagation.

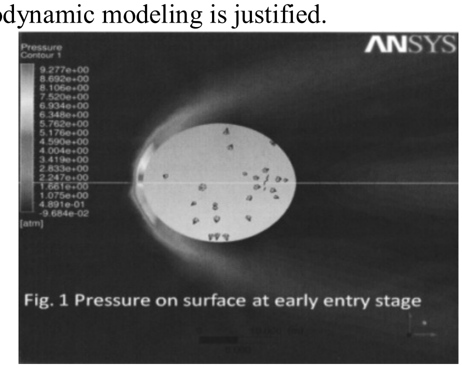

Fig. 1 Pressure on surface at early entry stage

The elastic mechanical values under determination where the Poisson' ratio, Young' modulus and ultimate strength in tension and compression. Experimental features of fracturing under the 3-axial load show a significant differences in the development of cracks for component A and B (see Table 1). At the same time we create analytical model of a cylindrical sample compression by various pressure from ends and sides using well-developed theory of rock deformation [4].

Conclusion: Generally, we have demonstrated that mechanical strength of macroscopic B samples is less that of A due to number of large voids. In addition, the interdace of A and B material are the planes of contact of the materials with the different strength. The record of Chelyabinsk' fall shows that the meteoroid was fragmented on to at least two large masses, probably due to the prpopogating of large cracks from the point of maximum load along the veins at the impact melt through the meteoroids body.

Table 1. Elastic and strength properties of the meteorite' Chelyabinsk components (from [2])

Sample, type	Density (g/sм^3)	The modulus of deformation (MPa)	Poisson ratio, ν	Angle of main cracks (α °)	Compression end/side (MPa)
A	3.245	17940	0.17	0°	141.99 / 10
B	3.315	16839	0.21	32°	124.02 / 5

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