EXPERIMENTS ON BREAKING CAST IRON BLOCKS WITH DYNAMIC LOADING

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It was noted in [1, 2] that with the use of high-energy impact devices there is a sharp increase in the effectiveness of rock breaking. Known works (see, for example, [2-7]) which consider various aspects of the interaction of an impact tool with a breakable rock mass do not contain sufficient information in order to explain this phenomenon. Apparently one of the reasons for this is the fact that in crushing rocks it is difficult to follow the nature of breaking due to overbreakage in the area of contact of the tool with the material being broken. Therefore a brittle material was selected for experiments, i.e., cast iron, which exhibits some ductile properties. The process of breaking during crushing of a quite uniform object (cast iron) is distinct from that with rock breaking (see, for example, [1, 5, 7]). Understanding the nature of cast iron breakage under the action of a blunt tool on a block of material may suggest the nature of breaking for rocks and ways of intensifying the breaking process for cast iron (the last question is connected with optimizing scrap processing).

An experiment was carried out for crushing of cast iron scrap with a hydropneumatic hammer of the projection type M100 with an impact energy up to 0.1 MJ. The hammer was tested in the Cherepovets Metallurgical Combine in unit AD1 prepared according to the technical documentation developed together with the M. A. Lavrent'ev Institute of Hydrodynamics and the special planning bureau of hydroshock technology in the Siberian Branch of the Russian Academy of Sciences.

Breaking of materials with the M100 hammer was carried out by applying successive strikes on the material [8]. The striker was 3 m long, it weighed about 1.5 tons, and the contact velocity of the striker with an obstacle could exceed 10 m/sec; the length of the striker exceeded the thickness of the block being broken by several factors. In addition, a replaceable tool was placed at the end of the striker, i.e., a head whose cross-sectional area was an order of magnitude less than that of the striker. In experiments the blunt head had a central hole. At the instant of impact the head fulfills the role of an elastic spring between the striker and the object which leads to a marked increase in the time of load operation on the material being broken. Therefore, a plane loading scheme was selected in the numerical experiment [9] both with respect to time (double travel of a compression wave through the block), and with respect to distribution the intensity of the applied load corresponds to a dynamic process which is realized in a full-scale three-dimensional experiment.

Some features of material breakage are noted. Before complete breakage it is necessary to apply to the block at a single point up to 10 strikes (energy of a single strike 0.1 MJ). A depression forms in the cast iron surface where they are applied equal in diameter to that of the head with a sharp impression of the central hole in the head (Figs. 1 and 2 where typical samples are shown which form with crushing of cast iron from the side and from the direction of the striker, i.e., in the impact direction, respectively). At the instant of breaking this depression does not as a rule exceed 5 mm. Visible macrobreakage starts as a single or several cracks directed radially from the depression formed, and in the majority of cases the cracks do not propagate into the deformed zone. The fracture surface is normally perpendicular to the surface over which strikes were applied. In the cross section in the area of fracture there was always a comapcted zone or core having the typical shape of a shell or wedge head (depending on the configuration of and thickness of the broken object); the maximum diameter of the core at the impact surface is about equal to that of the head, and its height is 0.55-0.65 of the head diameter. At the instant of material cleavage this core is often entirely separated from the fragments formed (see Figs. 1 and 2).

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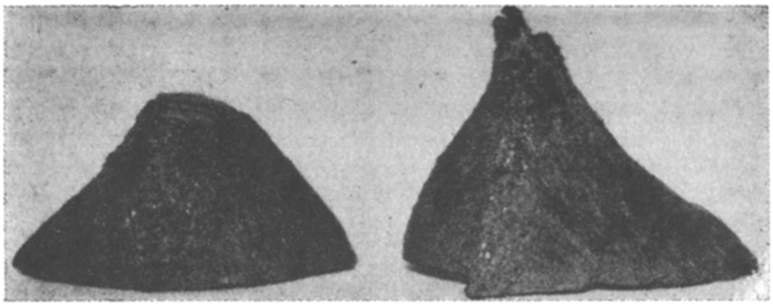

Fig. 1

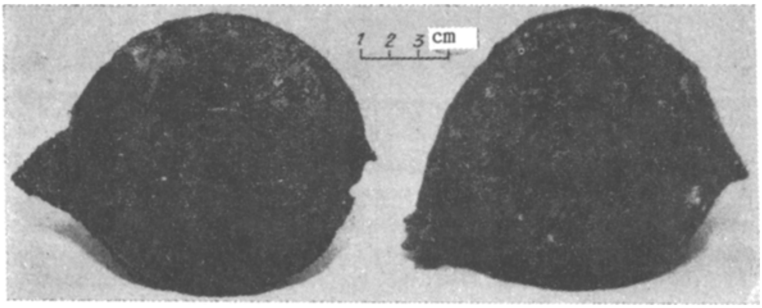

Fig. 2

The shape of the core coincides quite closely with that of the main pressure volume considered in [2], although its height is much less than that of the main pressure volume (0.77-1.06 of the diameter) calculated on the basis of the concepts in [2]. In addition, the shape of the core corresponds to the nature of breakage predicted in [9, Fig. 6] according to which separation of a block into parts is connected with occurrence of a zone of tensile stresses ahead of a sharp wedge (in our case this zone is retained for quite a long time). A full-scale experiment did not confirm the suggestion in [1] that with a high-energy impact tool (head) the geometry does not influence the effectiveness of breaking.

On the basis of experiments for breaking of cast iron blocks it may be assumed that with high-energy impact rock breaking in the last stages of the process in front of a blunt tool (similar to the experiments performed) a "conical" head forms which is separated from the material being broken by a zone of sliding. After completion of the breaking process, i.e., separation of the object into parts, this conical head is itself entirely or partly broken due to interaction with fragments and removal of the hydrostatic component of stresses with unloading.

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