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ANALYSIS OF THE REASONS FOR LOW ENERGY EFFICIENCY OF MINERAL RAW MATERIAL GRINDING PROCESSES

Nowadays, at the beneficiation of magnetite ores, up to 80% electricity consumption related to the technological cycles of crushing and grinding raw materials. Modern research aimed at reducing energy consumption focuses on the processes of selective mineral liberation. The key issue in this context is modeling of crack development beyond the limits of mineral grain fusion. Since the final stage of main fracture development is not covered by any of the current fracture theories, none of the existing ones can adequately describe the phenomena of selective fracture of ores. All studies on directed selective fracture can be divided into three groups: 1) explosion and crushing processes, which allow to obtain products of several tens of centimeters from the initial ore size of several meters; 2) grinding processes to obtain material with a particle size of 0.5-0.001 mm; 3) ultrafine grinding processes using nanotechnology to obtain material with a particle size of 1-0.001 μm.

The results of the analysis of existing technologies in these areas prove that the nature of destruction at each stage is determined by different parameters [1,2]. The difference between the second and third groups of grinding processes is not so much in the size range as in the determination of the parameters of the impulsive impact of selective opening of minerals. Studies [1] have determined that for the “realization of selective destruction, it is not so much the physical and mechanical properties of minerals that are important as their ratio, especially the ratio of the strength of the growth boundaries of the minerals in contact. Since magnetite fracture occurs mainly in size classes of less than 0.05 mm, it is modeling the fracture process during fine grinding that is promising for research. Finding an intermediate region of 10-1 μm in size, which belongs to fine grinding, belongs either to the second or third area of study and, accordingly, to different theoretical foundations of fracture.

After evaluating various scientific approaches, we can identify the contradictions of low energy efficiency of magnetite ore grinding processes. These reasons are:- significant (by orders of magnitude) discrepancy between the number of destructive elements and the number of destructive impact elements, which leads to a low probability of particle selection into the destruction zone, as well as to an increase in the number of cycles of converting electrical energy into gravitational energy of grinding bodies and to an increase in total energy consumption;- excessive excess of the energy of mineral destruction impact over the maximum required levels of destruction of the elements of the crushed medium (ore particles of a certain class).

This paradox was investigated. The difference in energy consumption in conventional crushing and disintegration for mineral disclosure is due to a significant difference in the total size of the fracture area and the splicing surface. Thus, the specific fusion surface of magnetite is in the range of 10÷320 mm2/mm3. The measured value of the specific fracture energy of iron ores in bending is in the range of 10÷250 J/m2. Even at the maximum value of the specific fracture energy, we obtain a range of energy consumption of 0.2÷7 kWh/t for the specified area of the ore splicing surface, which is several times less than the actual consumption during conventional crushing. It is possible to reduce this energy by applying pulse impact at the stages of primary ore preparation. We propose to model this process using nanotechnology approaches.

Thus, considering that the fracture mechanism of all solid materials follows the same principle—breaking the chemical bonds of the crystal lattice through the creation of a specific dislocation density—it is possible to model the dependence of energy consumption for crack initiation on the magnitude of the impulse impact. However, progress in improving the energy efficiency of ore preparation processes cannot be expected until the discrepancy between actual industrial grinding energy consumption and the physical necessity of energy input for disintegration is resolved.

References

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