technology in mines, quarries and mineral processing plants, the foundation for high-quality ore and production efficiency.

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NUMERICAL MODELLING OF THE INFLUENCE OF THE PLATE TAPERS ANGLE ON STRESS OCCURRING IN A CUTTING WEDGE OF DRILLING CUTTERS

Natural stones, such as marble, granite, limestone are traditional high-quality materials are widely used in construction and constitute an important source of economic wealth. The international natural stone quarry production sums up to 68.7 million tonnes per annum and is characterised as a low-tech, traditional sector with fragmented commercial activities and small size of companies [1].

Speaking about granite extraction, electrical energy, cooling water and steel are the major industrial requirements [2]. The resource efficiency of granite production chain is 0.31 [2]. Diesel fuel combustion for transport activities is the greatest contributor to GHGs emissions (68 %) compared to the purchased electricity and explosion process, with 31 % and 1 %, respectively [3]. Ukraine annually extracts about 104 million tonnes of granite; however the domestic mining industry still uses energy intensive techniques [4]. Implementation of the EC directives for building products and for energy efficiency in buildings impose the requirement for evaluation and reduction of the energy consumption in stone quarries. Therefore, despite minor share of drilling processes in energy consumption for granite extraction, it is actual to improve their energy and resource efficiency. Furthermore, in open cut operations the need to be competitive with world markets has place a heavy demand to be able to drill and blast considerable tonnages of ore in the quickest possible times [5].

There are a lot of factors of the drilling performance, for example, blast pattern [6], tools [7], pre-existing cracks [8] etc. In this article, the parameters of the drill cutters will be considered with the use of modelling.

The study of the processes of rock destruction by working tools (cutters) and the selection of their design parameters are complex tasks that are solved mainly experimentally. Modern methods of mathematical modelling eliminate the need for long and expensive experiments.

In this work, the influence of factors on stresses in the cutting part of drill cutters characterizing its strength was investigated. Using the developed numerical model, studies were carried out to establish the influence of plate size and sharpening angle on cutting strength parts to determine the maximum tensile stresses on the front edge of the incisor.

The studies were carried out with a chip thickness m=2, a back angle α=25 ° and with a variation in the point angle δ = 50- 95 º with a step of 5 º. The values of the maximum contact height h, forces acting F_x, F_y on the cutting wedge of the cutter, and normal stresses σ_{max} arising in the reinforcing plate were calculated and summarized in Table 1.

Table 1

The results of the calculation

δ, deg	50	55	60	65	70	75	80	85	90	95
h, mm	0.80	0.84	0.88	0.92	0.97	1.03	1.09	1.17	1.26	1.38
F_x, N	290	337	385	414	476	575	679	788	995	1138
F_y, N	-70	-57	-32	9	42	101	180	286	464	657
σ_{max}, MPa	1117	1005	875	719	620	558	481	414	362	316

According to the results, the maximum normal stresses take place on the front face. At sharpening angles δ>90 °, the maximum normal stresses slightly decrease, but the cutting forces increase significantly. Consequently, it is impractical to use drill cutters with taper angles of more than 90 degrees, since they do not provide high work efficiency. It is possible to select the minimum allowable angle of sharpening of the cutting part of the drill bit for specified application conditions, characterized by the contact strength of the rocks of the field, under which its strength and high speed of drilling will be ensured.

Conclusions

1. Numerical studies of the stress-strain state of the cutting part of the drill bits make it possible to determine how the structural parameters of the drill bits have an influence on their strength and drilling efficiency. In this case, it is possible to determine the critical values of each parameter taking into account the strength of the cutter and drilling efficiency.

2. Modelling using the finite element method provides a fairly accurate solution to the problem of the stress-strain state of drill bits, which enables the design of new drill bits to select rational structural parameters of the elements of the cutting part under the condition of strength.

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