NEW METHODS AND INSTRUMENTS IN MINING

DEVICES FOR CONTINUOUS RECORDING OF THE PARAMETERS OF DEFORMATION — WAVE PROCESSES IN ROCK MASS. PART I: MEASUREMENT OF LONGITUDINAL MOVEMENTS OF ROCKS IN A BOREHOLE AND DESIGN OF THE POSITION SENSOR


A sensor for measuring movements in block rock mass through boreholes is presented. Being an organic part of multichannel instrumental set, the sensor ensures revealing of deformation changes in the controlled zones of block geomedia, which is of key importance when stress variations and fatigue failure in rock mass are determined.

Rock mass, sensor, measurement error

INTRODUCTION

In order to reveal the mechanisms of rock bursts in mines, it is necessary to study mining-induced movements of structural inhomogeneities of rocks, rock stratum displacement, and deformations. It is required to measure displacements of geoblocks and strains at different points of a massif depending on location of these points relative to underground working contour in geomedia with both natural and induced jointing, and with allowance for structural features (disintegration zones, tectonic faults, pillars or filling masses failed by rock pressure or blasting, etc.). Based on this, the Institute of Mining and the Engineering and Design Institute of Scientific Instrument-making of the Siberian Branch, Russian Academy of Sciences, have designed a prototype of a borehole multichannel optoelectronic longitudinal deiformometer (from here on meter) [1, 2]. The meter was brought into accord with the objectives of remote geomechanical monitoring of block geomedia in underground conditions, and with the requirements of the normative documents and guidelines for safe mine operation [3–6]. As the basis of the development, the Russian Federation Patent No. 2097558 was used [1].

PRINCIPLE OF MEASURING DISPLACEMENTS IN ROCKS

The technical solution of measuring displacements of geoblocks in a rock mass is based on a “slide gauge idea”. The idea is realized using a measuring bar, which is fastened inside the massif in a borehole, and a position sensor with his sensing element attached to the rock and capable of moving freely along the bar. The bar consists of sections connected by pipe couplings. The sensor is set on a section of the bar. By doing so, we ensure the modular gathering of the instrument.

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Measurements in rock masses are frequently conducted using horizontal boreholes drilled in mine working walls towards the section to be controlled. In this case, the borehole (Fig. 1) usually intersects rock blocks \( C_1, \ldots, C_i \) formed by disintegration zones \([7, 8]\) and gets deeper in an intact massif part \( C_n \). Prior to installation, we need to choose a reference point \( O \) in \( C_n \), check points in geoblocks \( C_1, C_2, \ldots, C_i \) between the zones of disintegration, and number of sensors.

The bar sections and sensors built a pickup probe. Measuring bar 2 is fastened at the reference point \( O \) via support 1 (Fig. 1). According to the number of controlled blocks, sensors 3 are installed on the bar with the sensing elements fastened to the rock at the points \( C_1, C_2, \ldots, C_i \) (here and further, the check points and the corresponding blocks are denoted by the same letters). Having such arrangement, displacement of the \( i \)th block under control will cause the same displacement of the sensing element of the corresponding sensor along the bar, which is recorded by an electron device.

The sensor measurement range may be chosen using the known relation between the values of crack opening and linear dimensions of crack-separated blocks in the structural hierarchy of rock mass \([8]\):

\[
\mu_\Delta(\delta) = \frac{\delta_i}{\Delta_i} = \Theta \cdot 10^{-2},
\]

where \( \delta_i \) is the mean “opening” of cracks (distance between their edges), \( \Delta_i \) is the dimensions of blocks of the \( i \)th hierarchical level, and the coefficient \( \Theta \) for any \( i \) is most often in the interval \( 0.5 - 2 \), i.e. \( \Theta \in [0.5 - 2] \). In the general case, “opening” is understood both as the width of open cracks and the thickness of zones of intensive rock crushing around various-level tectonic faults (zones of weak-adhered rock fractures).

By the data of surveying services, for example, in the Norilsk deposit mines, it is known that in the majority of cases, the typical depths of rock falls in mine working walls vary from 0.5 to 2–2.5 m, and sometimes reach 3–4 and even 8 m (in working roof, as a rule). If the fall depth is assumed as a linear size of a separated block, relation (1) may be used to estimate the crack “opening”. For the mentioned dimensions, these “openings” will fluctuate from 2.5 mm at \( \Theta = 0.5 \) to 80 mm at \( \Theta = 2 \). Coming to nothing more than \( \Theta = 1 \) and taking into account that blocks are seldom separated for more than 3 m depths, the crack opening may be from 2.5 to 30 mm. In compliance with this, the sensor measurement range may be assumed from 0 to 30 mm, which is admissible by specifications of measurement devices, as was confirmed by the experiments in the Norilsk mines \([7]\).

![Fig. 1. Scheme of measuring bar and sensors in borehole](image-url)