

*Jerzy Stasica**, *Zbigniew Rak**

INTROSCOPIC CAMERA TO EXAMINE ROCK STRUCTURE PENETRATED BY DRILLING OPERATIONS

Since few years, at the Underground Mining Department of the Academy of Mining & Metallurgy, Cracow, Poland, researches have been carried out to adapt the infrared introsopic camera to examine structure of rock penetrated by drilling operations. The term rock structure is considered to comprise petrographic structure and tectonic fissility, including secondary fissures effected by mining operations.

An intention of the authors has been to construct an instrument enabling the mine geologist to recognise a kind of drilled rock, without any need to sample a drill core. Besides, from the point of view of mining operation effectiveness, abilities to survey low cohesion planes, fissure gaps, and fissure spacing in respect to a borehole outlet, are very important too.

After some two-year experiments in situ using a camera (Fig. 1), the instrument occurred to be of a highest serviceability to geological and mining specialists operating in heavy-duty mining conditions.

Superiority of the instrument, over other widely known stratification-meters in respect of examination and surveying rock fissures, consists in its capacity to check and to survey fissures just by a first test. The infrared video camera is able also to find fissures filled with drill dust. Therefore, application of the camera is useful in checking of any-type stratification-meter readings, especially if readings are close to critical parameters defined in a rockbolting design (Fig. 2).

The camera's element being inserted into a drilling hole is the camera head furnished with a photo-optic system built-in, together with a lens, into a casing of a tube shape. The 120 mm long casing tube has a diameter between 18 mm to 35 mm depending on a purpose.

* AGH University of Science and Technology, Krakow



Fig. 1. Introsopic camera to examine rock structure penetrated by drilling operations

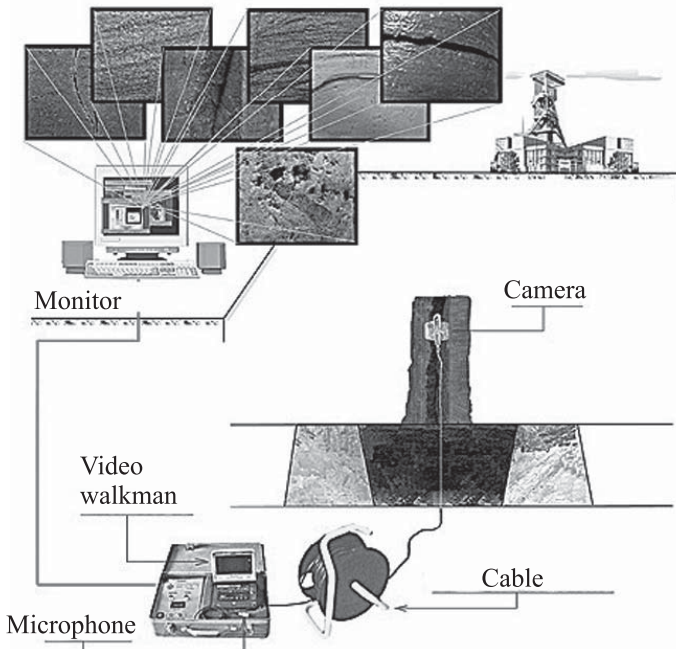


Fig. 2. The block diagram of the introsopic camera is shown in the

The camera head is inserted into a borehole being suspended on lightweight tubes of glass wool, joined together with bayonet joints.

In vertical down-pointing boreholes, the camera head can be lowered using a signal cable. The self-adjustment device of the electronic system enables penetration of a borehole down to a depth of 200 m, and neither image sharpness nor its quality are lost.

The system includes also a monitor display, and a VHS video recorder if required. Verbal commentaries together with the image can be recorded on a video tape presenting current comments of a displayed picture, marking depths of displayed objects, etc.

Recently, a system of automatic surveying of the camera head depth in the borehole and its recording on a video tape has been elaborated for a purpose of mine investigations.

The whole apparatus system is supplied by a 12 V battery sufficient for 6 hour continuous operation.

All components of the camera are contained in a regular-sized easy-to-handle suitcase, therefore operation of the system in underground mine conditions is rather easy.

Previous experience of camera operation shows that it can be used also to survey fissure gaps and fissure inclination in a hole. Such measurements of fissures can be performed on an image displayed on the monitor, immediately during tests performed in the mine underground, or afterwards while viewing the video tape on the surface. Accuracy of fissure gap measurement depends on the size of a monitor.

The visual field of the lens mating with the camera designed for a borehole of 45 mm dia is 12×12 mm and such a visual field fills the monitor screen. Using a monitor screen of 17" diagonal for image survey, accuracy of fissure gap measurement of 0,1 mm (or even better) can be provided — see Figure 3.

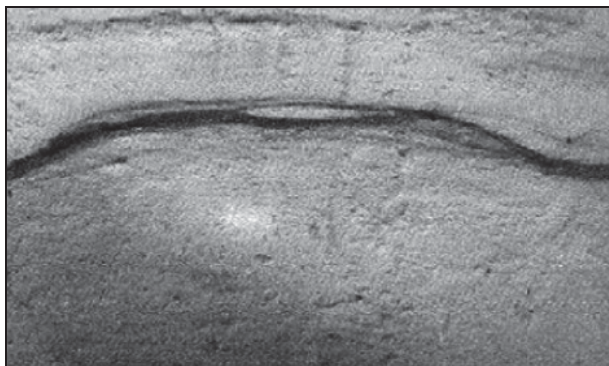


Fig. 3. Image of the fissure crossing the borehole

Having few images of borehole walls of the same borehole segment taken in various time, corresponding images can be compared and differences of fissure gaps and fissure locations can be measured, thanks to a special card installed in the computer. The same measurement can be performed without usage of the computer, using only a video camera and monitor.

In such a case images of borehole walls, recorded during observation of the borehole interior, are studied and fissure gaps and their locations measured.

A multiple penetration of the same borehole using the camera and an ability of image examination by a computer enable to keep track of rock mass fissuring development.

Currently, a new version of the camera with a special built-in digital video system is under construction.

The video system has capacity to record either a continuous picture or a frame picture. All reading parameters are automatically set up. The picture is recorded in a 520/380/256 definition of grey scale in a compressed format.

After return from a mine underground, the modified camera can be connected to any computer and the whole picture sequence, or only its required sectors, can be transferred into the computer memory. Examination of photographs, their recording and storage, are to be performed using a PC-Pentium computer type. The software enables to view recorded frames of a film, their contrasting, band filtering and solarisation intended to ease perception of a low contrast image.

An integral part of the system is a software enabling to carry out numerical and comparative analyses and archiving. The comparative analysis program is able to catch automatically a difference in pictures imaging the same segment of a borehole as seen in various tests. An image coming from the camera can be visible, as required, either on a monitor and printed on a computer printer in its actual shape, or as for instance a map of isolines of points identically spaced to the lens axis (Fig. 4 and 5).

The image analysis system associated with a digital video system enable a complete automatic image processing. The image is sharpened, and soft-focused and/or illegible image frames are deleted. The system arranges images in a continuous column, by means of an artificial neurone network, next it decodes information about the camera location, and marks out a millimetre scale on the picture.

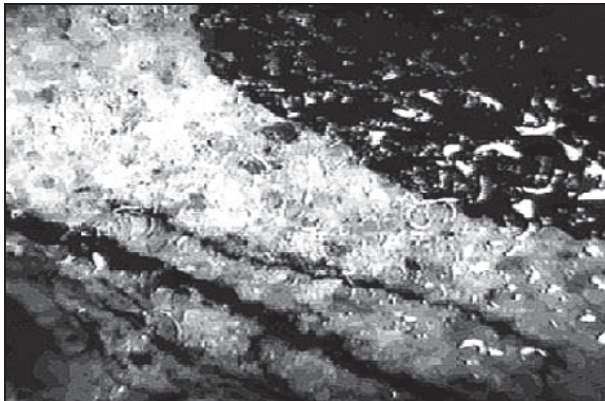


Fig. 4. Image of a borehole wall with its visible granular structure and fissures

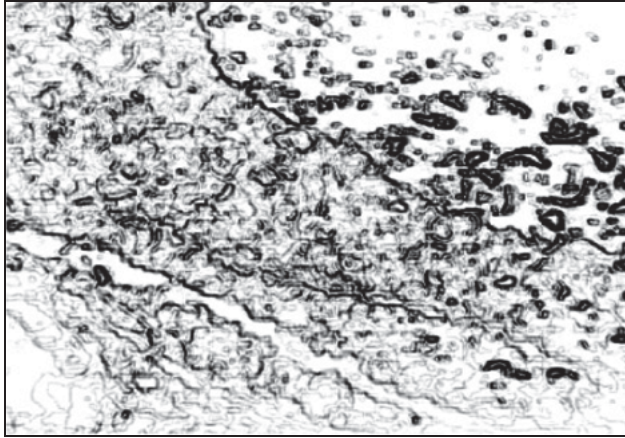


Fig. 5. Granular structure of a borehole wall in a form of isolines

All areas, of specific features pre-defined by the user, are searched out and recorded on separated photographs, arranged in a subject order. The whole process is performed without operator control, and it examines final data processed by the computer.

The result in a form of composite photographs (whole columns), and after their compression, can be archived on floppy disks or RCD-ROMs.

The infrared camera enables also to define, with a high accuracy, a fissure zone formed in a roof and/or side-walls and/or floor of the examined excavation. Camera exploration can be performed in boreholes filled with water.

Accuracy of the method, presented herein, its easiness of observation performance, univocal interpretation of investigation results, as well as possibility of identification of actual fissure situation already on first observation tests, allow to pronounce a favourable opinion of the method usefulness for stability control of mine excavation roofs, side-walls and/or floors, including control of rock mass surrounding vertical excavations.

The introsopic method of rock structure survey, as described above, requires only to drill boreholes. "Cutting" deformation of a borehole, that appears sometimes, makes a multiply observation of the hole impossible.

The method in question is a valuable tool during a phase of designing an excavation roof bolting support or reinforcement of an existing excavation with bolting, particularly in case of a high-type roof bolting support. The method provides a quick identification of location of drilled-through strata limit planes, as well as identification of strata types even close to a roadway face.

The camera is used successfully for definition of minimal lengths of bolts in case of reinforcement of existing roadways and/or crossings in steel arching or bolting support.

Successful examples of underground work completed by us in the Polish coal mines can be found in the mines: Ziemowit, Czczcott, Piast, Myslowice-Wesola, Murcki & Staszic.

Recently, we have commenced to implement a new technology of mine roadway floor protection by inserting ropes. Thanks to application of the above described apparatus system, we were able to study the shape of floor heave to define an optimal method of its reinforcement.

The introsopic method was used also to identify a degree of damage of brick and/or concrete walling of shaft bottoms, shafts and chamber excavations for a purpose of special work to reconstruct and/or reinforce such underground excavations.