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Atypical and innovative tool, holder and mining head designed for roadheaders used to tunnel and gallery drilling in hard rock

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ABSTRACT

The paper deals about atypical and innovative solutions of mining cutting tools, their holders and mining heads designed to drilling galleries and tunnels in hard rock – using roadheaders. If standard tools – tangential-rotary picks and milling heads are used, hard rock mining usually leads to quick and significant wear of mining tools. In Department of Mining, Dressing and Transport Machines, AGH UST in Krakow innovative and atypical mining tools were developed – crown picks and asymmetrical mini disk tool, especially for hard and very hard rock mining. For cutting tools (both standard and new type) a special solution of lubricated holder was also developed, allowing to facilitate and increase the number of pick rotations in the holder, as a consequence, reducing wear of the tool. The results of laboratory tests, obtained with new solutions of tools and holder, were described. On the basis of received results new solutions of mining heads were developed and manufactured. The prototype of mining head with crown picks, mining head with lubricated holders, and mining head with disk tools with complex motion trajectory were described and presented. Series of field tests, using new mining heads, were described. Final results and conclusions were presented.

1. Introduction

In underground mining industry most of the open-dog and preparatory headings or tunnels are drilled with mechanical methods – applying arm roadheaders. In recent decades, the problem of mechanical hard rock cutting in world mining – related to deeper mineral resources seams and driving workings in harder rocks containing more highly abrasive inclusions – has become more intense. It was related mainly to small-cutting advance rate and very high cutting tools wear of the shearers and roadheaders, so the cutting process became economically ineffective. The attempts directed for application of new type cutting tools, mainly tangential tools with sintered carbide inserts of increased diameter and disc cutters with small diameter, did not lead to successful results when applied for hard rock cutting. Therefore, the steps to develop new rock mining techniques have been undertaken. In the Department of Mining, Dressing and Transportation Machines, AGH University of Science and Technology in Krakow, new solutions of cutting tools, their holders and mining heads were developed and successful investigation of rock mining techniques with use of these tools and mining heads has been performed. These mining tools and heads were designed especially for roadheaders. The construction solutions of new innovative and atypical mining tools, holders and heads, working modes and results of performed laboratory and industrial researches are described below. The article presents the results of researches carried out (among others) as part of research projects no. 9T12A00715, 4T12A00528, 6T122003C/06057, founded by Polish National Centre of Research and Development and National Research Centre.

2. New construction of cutting tool

The shape of the sintered carbide insert for tangential rotary picks is usually in a form of a rotary body, consisting of cylindrical and conical parts. Linear and angular dimensions of the insert are selected considering properties of the mined rock and mining resistance and wear (durability) connected with it. According to conducted tests, the most favourable solutions are carbides of the cap and mushroom types with the diameter larger than 20 mm. But even new solutions of carbide inserts do not allow very hard rock cutting. High hardness of the carbides is often the reason of their chipping, brittleness, and in consequence breaking. It leads to large wear or damage of tangential rotary picks (Barker et al., 1981; Evans, 1984; Krauze, and Kotwica, 2007, Powell, 1991). That is why many research lead towards development of new design solutions of cutting tools and their holders has been

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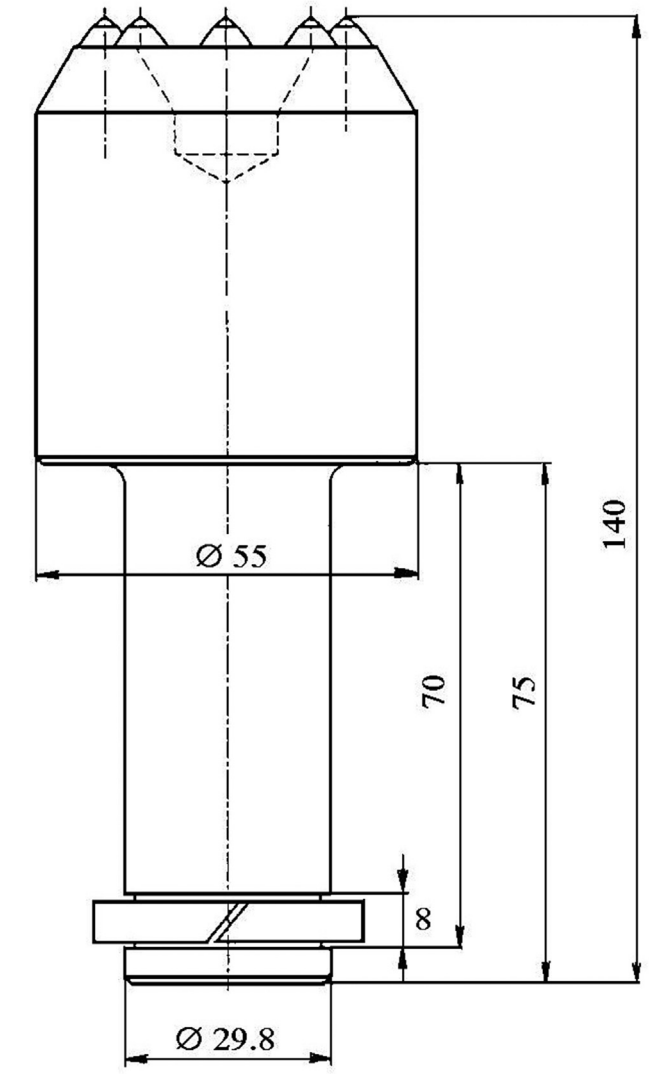

Fig. 1. Scheme of the new type of the crown pick (Gospodarczyk et al., 2006).

conducted in order to allow hard rock mining.

The first solution comprises special tools, which can replace traditional tangential rotary picks. This tools are adapted to attach in standard holders of tangential rotary pick which are commonly used for hard rock cutting, whereas design solution of the picks working part is different than those designed for the standard tangential rotary picks (Gospodarczyk et al., 2006). The new pick is shown in Fig. 1. The cutting segment is bell or crown-shaped, and the working part is armed at the circumference with eight cone-shaped sintered carbide inserts. Such design solution, instead of traditional cutting with use of standard tangential rotary picks, should allow loosening rock fragments as a result of point pressures exerted by individual sintered carbide inserts. Moreover, non-uniform load of individual sintered carbide inserts should cause increase the tool rotary speed in the holder, at minimal side deflection angle of the cutting tool. After manufacturing of the new tool prototype, preliminary tests at a special laboratory stand were carried out. The tests were carried out on the special laboratory test stand for single tools testing, which has been subjected to some modifications in order to create similar to real pick edge working conditions.

The laboratory stand (Fig. 2) consists of a frame 1 along which a traverse 2 is moved vertically. A slide support 3 with a cutting tool-holder 4 of L shape is mounted on the traverse. The support can move along the traverse. The measuring system enables an independent

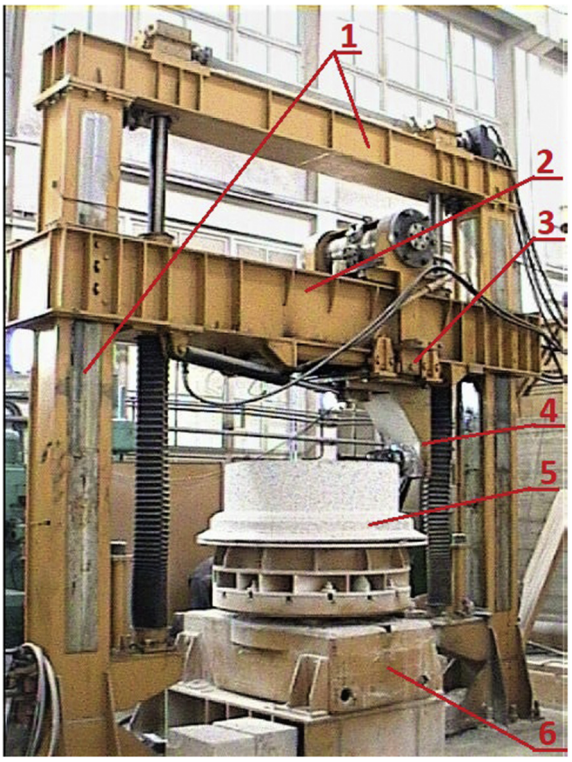

Fig. 2. View of the laboratory stand for single mining tools – description in the text (Gospodarczyk et al., 2006).

measurement of cutting force components: tangential force Ps, pressure force Pd and side force Pb. It is mounted on the tool-holder, on the lower part of the longer arm. The standard tool-holder, on which a cutting tool is directly mounted, is was used. The holder is installed in such a way that the picks can cut in the layout which is close to that occurring on the cylindrical part of transverse mining heads, i.e. at setting angle $\kappa = 45^{\circ}$ and side angle $\rho = 8^{\circ}$. The artificial concrete or natural stone sample 5 in the shape of ring is mounted in the axis of the stand and is rotated using hydraulic drive 6. The sample is cut by the test tool on the side surface, from the top to down with set cutting depth (Gospodarczyk et al., 2006).

The results of preliminary researches has been satisfactory. Significant rotations and very small wear of new tool were observed. In the following sequence, several new tools were made with a different number and diameter of carbide inserts. The working part of the tool was additionally changed by introducing rounding of its side surface. View of a set of new crown picks is shown in Fig. 3.

As a consequence of the research the best solution of the new tool has been chose. Wear, load and number of tools rotations were measured and compared. The best results (lowest tool load, low wear and largest number of tool rotations) were obtained with the pick with 8 carbide inserts with diameter of 8 mm. Fig. 4 presents the view of this crown pick after sample mining on the total distance of 1200 m. This type of the new tool has been applied in the new solution of roadheader mining head.

3. Lubricated holder for cutting tool

The shape of the rotary tangential pick and proper method of its mounting in correctly selected holder allows its free rotation and even wear. Obviously, the shape of the tool expressed by linear and angular dimensions and properties of the material used for constructing the body, holder and edge have to meet certain requirements required by proper realization of the cutting process (cutting angles) and the length of operational time (durability). Determination of the requirements will