Stress-Deformed State Knots Fastening of a Disk Tool on the Crowns of Roadheaders

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Abstract: Presents innovative technical solutions, research results and recommendations based on mine testing and modeling of stress-deformed state knots of fastening disk tool for different variants of the structural design, including many-sided prisms at destruction faces crowns roadheaders selective action.

Keywords: Roadheader, effector, crown, triangular prism, knot fastening, disk tool, destruction, crushing, loading, stress state, finite element method.

1.Introduction

In the leading mining countries the main means of mechanization for mining are Roadheaders. Improvement of effectors of the boom-type roadheaders and heading-mining combines by rational combination and the placement of cutter and disk tool for the implementation of the principle of destruction of coal and hard rock large-sized is an actual problem. This disk tool implements the possibility of the reverse motion of the working bodies of the model of mining machines, including crowns roadheaders, increasing the scope of their application to the destruction of the heterogeneous, hard and abrasive rocks [1].

2.Experience of application of disk tool

Disk usage of tools for crowns of roadheaders selective action is a perspective direction in development of efficient rock cutting tools for mechanical destruction method of coal and strong abrasive rocks with the hardness coefficient $f \leq 10$.

It is confirmed by researches at the chair of mining machines and complexes KuzSTU named T.F. Gorbachev. Tested four types of crowns roadheaders selective action, which are distinguished by the number of cutters and disk tools, step-install them, screw-line set of working tool, the design of the knots fastening disk, cutting part of the crown and the presence of loading blades [2].

The method and conditions of mine testing implemented when working on ore and coal veins with hard inclusions and layers with compressive resistance (σ from 87 to 112 MPa).

The tests were performed in two stages. The first stage included research of the roadheader, equipped with a serial crown with cutters, the second stage included the experimental crowns, equipped disk tools. In the process of comparative research was determined by the force and energy performance of the roadheaders and the specific consumption of the working tools. General view, the scheme of recruitment and placement of rock cutting tools for experimental samples of the working bodies in the form of a longitudinal axis of the crowns of times-personal design is presented in fig. 1–4. Crowns are composed of the following structural elements: 1 – blank crown: 2 – disk tool; 3 – cutter; 4 – starting borer; 5 – cutting disc; 6 – loading the blade.

In fig. 1,a presents design, in fig. 1,b shows the assembly elements of the experimental model of the crown, on fig. 1,c depicted crown on the boom roadheader, as in fig. 1,d shows the knots fastening of the disk tools.

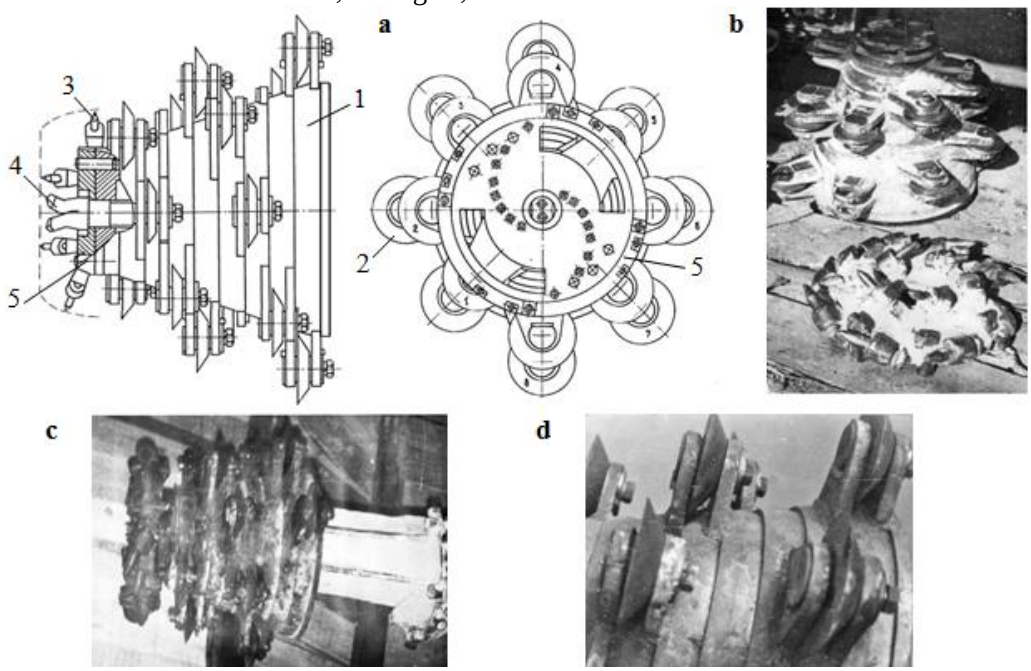

Fig. 1：The crown of the first type

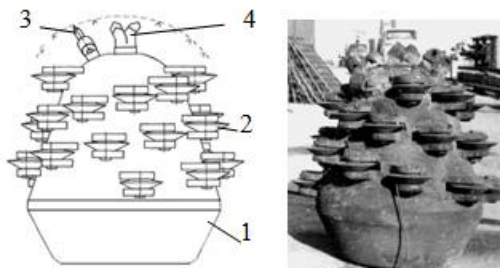

Fig. 2： The crown of the second type

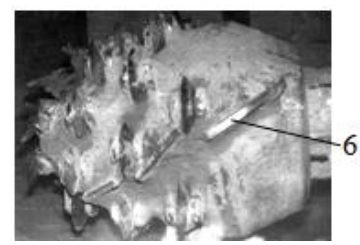

Fig. 3： The crown of the third type

Fig. 4：The crown of the fourth type

Fig. 5：Disc tool

For the study was made of disk tool of the same diameter D = 160 mm, but three designs (fig. 5). Disks first performance had at the angle of taper $\varphi = \varphi_1+\varphi_2 =$ 30+5 = 35 °. Disks second performance $\varphi = \varphi_1+\varphi_2$ = 25+5 = 30 °. Disks third of execution had the edge with curved teeth

profile with the angle of taper $\varphi = \varphi_1+\varphi_2 = 30+5 = 35°$.

On the crown of the first type (fig. 1) used the knot fastening bolted connection (fig. 6,a), and the other three crowns (fig. 2–4) was used "quick-dismountable" knot fastening (Fig. 6,b) [3].

Double-seat knot fastening (fig. 6,a) consists of two brackets 1 and 8, in which the axis 2 flange fixed conical disk tool 3 with remote rings 4. From the axial displacement of the axis 2 fixed washer 5, bolt 6 and spring washer and from turning axis 2 fixed planck 7.

In fig. 6,b shows double-seat knot fastening consisting of two brackets 1 and 8, in which the axis 2 is fixed biconical disk tool 3 with remote rings 4. For fixation of axis 2 of the inside of the right-bracket 8 is a slot 5 with locking ring 6 and rubber gasket 7, and in the left bracket 1 is executed a groove 9.

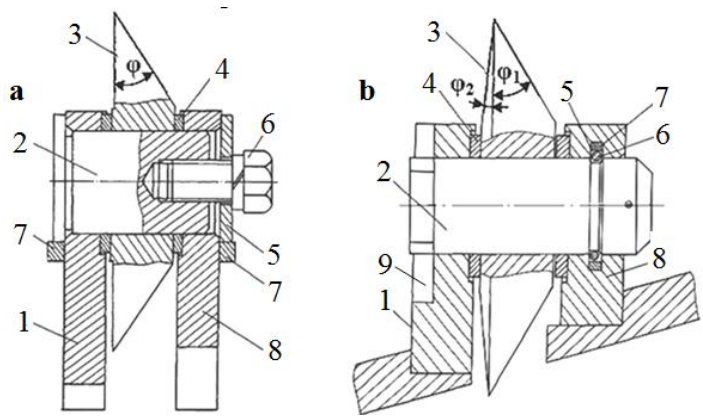

Fig. 6: The design of the knots fastening disk tools

During the tests revealed the complexity of direct cutting boom of the crown of the first type (fig. 1) due to high axial workloads. Design of the crown of the second type

(fig. 2) showed high efficiency, especially in the mode of cutting. At the crown of the third type (fig. 3) with loading blades was marked by the accumulation of sand and clay rocks and sharp deterioration of loading capacity, when working in water bearing layers. Design of the crown of the fourth type (fig. 4) unified on the basis of the second type (fig. 2), that is, truncated on the latter two knot fastening disk tools in each line cutting. There were received satisfactory energy and extended the field of application of the roadheader on hard rocks.

To obtain comparative data, characterizing the degree of loading of transmission and electric motor of the crown, were measured power consumption of the electric motor, the feeding speed of the crown and the pressure in the hydraulic system roadheader for indirect assessment of efforts arising from the work tool.

Currently one of the effective methods of research of stress-deformed state of knots fastenings disk tool and forming loads on a disk tool in the destruction of coal faces is the method of finite elements.

At the first stage of research on finite element modelling was carried on a double-seat knots fastenings (fig. 6,b) with the disk tools of various design (fig. 7) to establish the parameters of the stress state at the account of the characteristics of the destroyed mountain range $\sigma = 50 \div 140$ МПа [3]. Considered four variants of constructions disk tool diameter D = 160 mm (three biconical with angle of taper: $\varphi = \varphi_1+\varphi_2 = 25°+5° = 30°$; $20°+10° = 30°$; $15°+15° = 30°$ and one conical $\varphi = 30°$).

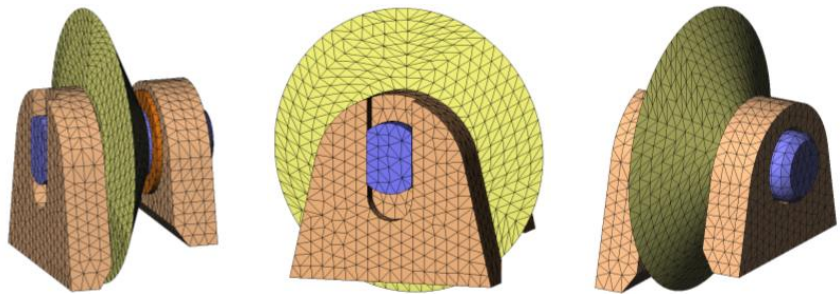

Fig. 7: Finite element model of a double-seats knot fastening disk tool

The calculation was made in the system SolidWorks Simulation. When creating a mesh was used parabolic finite elements in the form of tetrahedra. The size of finite elements was chosen so that a further increase in the density of the mesh not have a material impact on the results of the calculations. Material of details – 35HGSA. When describing the conditions of interaction between details in an assembly used the contact condition "No penetration". To fasten knot in the calculation were applied boundary conditions "Fixed", is attached to the bottom edge of the supports.

By calculation [3] were determined efforts cutting P_z, implementation P_y and side efforts P_x on a disk tools with regard to design, operating parameters and characteristics of destructive massif σ. Estimated efforts of loading P_z, P_y, P_x were attached to the finite element models (fig. 7) disk tools in the double-seat knots fastening, in which produced a picture of the stress-deformed state for biconical and conical disk tools (fig. 8) [3, 4].

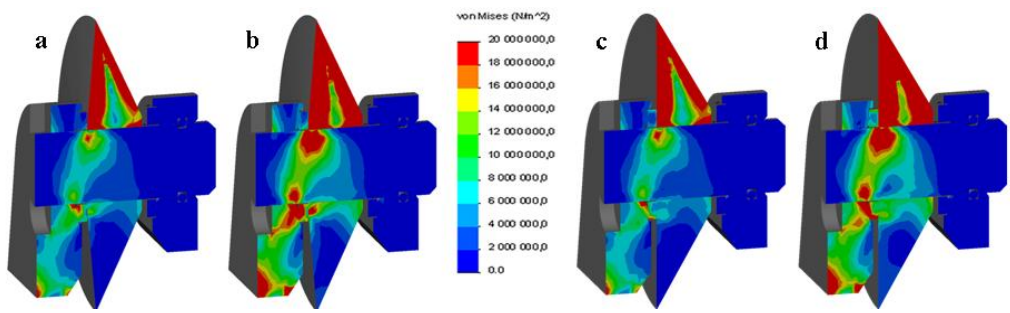

Fig. 8. The distribution of equivalent stresses on the criterion of Mises in the double-seat knots fastening: - for biconical disk tool (φ = 25 °÷5 °= 30 °) for conditions: a – σ = 70 MPa; b – σ = 120 MPa; - for conical disk tool (φ = 30 °) for conditions: c – σ = 70 MPa; d – σ = 120 MPa

In addition, gumming radially split between bearings spaces knot fastening the disk tool products destruction and their adhesion to the working surface of the blank crown and blades of decrease of efficiency of processes of destruction and loading of the rock mass on the loading table roadheader.

In practice underground coal mining known that roadheaders provide the driving of mine workings with given sizes of cross section (S) and width ($B_в$). Each roadheader (table 1) has the width of the loading table ($B_{п.с}$), a smaller width entry ($B_в$), which complicates the process of loading a bing of rock mass near the edges of mine [4].

The difference (Δ) between the width entry $B_в$ and width loading table $B_{п.с}$, characterized the presence of two corridors near the edges of mine not covered with the loading table.

Table 1：Mapping the width of the loading table with a width of mine

Roadheaders	Maximum cross-section entry S, м^2	Maximum width entry $B_в$, м	Width loading table $B_{п.с}$, м	The difference $\Delta = B_в – B_п$
1GPKS	17,0	4,7	3,02	1,68
KP21	28,0	6,5	3,4	3,1
SM-130K	19,0	5,005	3,0	2,005
П-110	30,0	6,7	3,8	2,9

In fig. 9 shows the circuit of formation tests strips from the bing not shipped products of destruction of a typical effectors roadheaders selective action: a – when operating radial crowns; b – in the operation axial crowns. The process of loading near the edges of mine is characterized by the following parameters: $B_{и.о.}$ – working width of the effector; $B_{лн.ш.}$ – width not shipped bing products of destruction at the left side; $B_{пн.ш.}$ – width not shipped bing products of destruction at the right side; $B_в$ – width project entry; $B_{п.с.}$ – width of the loading table, describing the width of the area of the front loading [5].

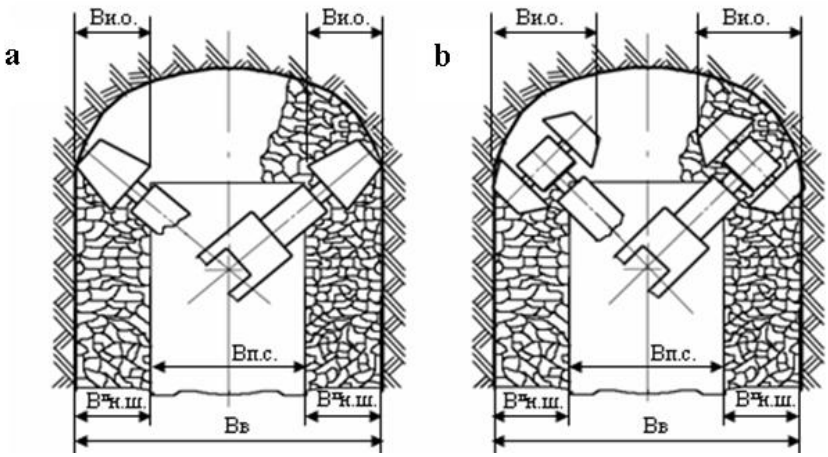

Fig. 9：The scheme of formation of the front loading at driving

One of the most important requirements to the construction of effectors of roadheaders selective action is the expansion of the front loading of near the edges of mine on the loading table. The application of the crowns of domestic and foreign production solid screw spirals improves the process of loading only one of the sides of mine working, but worsens it from the opposite side. However, even screw radial crowns do not cover the entire width of edge band at the loading table, forming spillages and demanding maneuvering and loading of back-circular races roadheader. This increases the duration of the operating cycles and reduce the rate of work.

It is therefore of particular interest to develop technical solutions in the reverse mode of operation radial crowns selective action to combine the processes of destruction of rock mass on coal face, crush oversized, and loading on the table of the roadheader in any edges of mine working [6]. The basic foundation of such technical solutions are knots console fastening disk tool on brackets in the form of triangular prisms [7–9].

Realization of these technical solutions will allow to expand the application domain swept roadheaders selective action on carrying out of mountain developments in the faces with heterogeneous-

structure of rocks in a wide range of operating conditions.

For the last 3-5 years, the department of mining machines and complexes KUZSTU named T.F. Gorbachev together with the department of mining equipment Yurga Institute of Technology, TPU conducted research work on the study of stress-deformed state of various designs knots console fastening the disk tool on brackets in the form of triangular prisms to reverse radial crowns (fig. 10) [10].

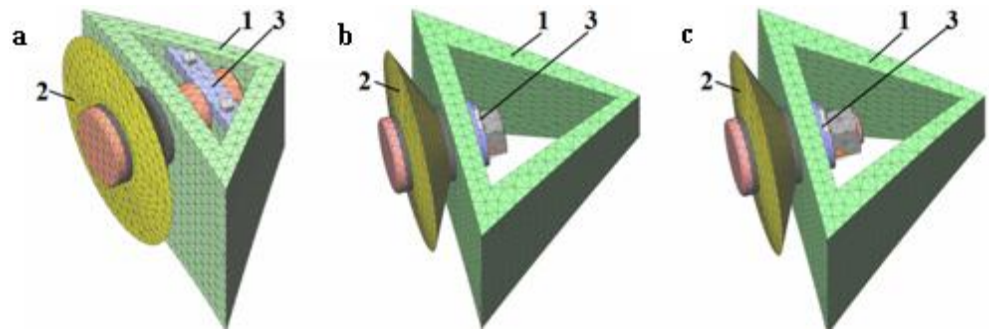

Fig. 10: Finite element model of three variants of constructions fixing disk tool to trihedral prisms: a – the first with strap-lock; b – the second with the mounting screw; c – third with nut; 1 – triangular prism; 2 – disk tool; 3 – knot fastening

In each design was used as a biconical and conical disc tools. Strategy in the construction of finite-element models and calculation of efforts loading P_z, P_y, P_x was similar to double-seat knot fastening of the disk tool. As an example in fig. 11[4] presents the distribution of equivalent stresses the Mises criterion for three variants of knot fastening disk tool diameter D = 160 mm in trihedral prisms.

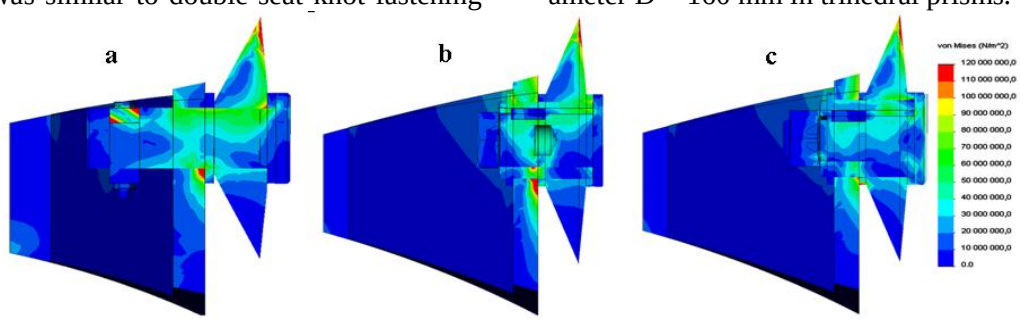

Fig. 11. The distribution of equivalent stresses in the Mises criterion for three variants of knots fastening disk tools with an angle of taper φ = 25°+5° = 30° in trihedral prisms taking into account the characteristics of the destructible array σ = 70 MPa: a – the first bar-lock; b – the second with the mounting screw; c – the third with nut

The technical solutions console knots fastening the disk tool on the trihedral prisms, taking into account the results of modeling of stress-deformed state in the destruction of coal faces, will recommend them for equipment of the working bodies roadheader, shearers and drilling combines of domestic and foreign production.

3.Conclusion

It is established that the equivalent stress on the criterion of Mises in all versions knots fastening disk tool radial crowns roadheaders significantly lower yield stress for steels 35HGSA (σ_T = 490 MPa). With the transition from the asymmetry for symmetry biconical disk tools can be traced reduction zone settings equivalent stresses in knots fastening with the general increase of the maximum stresses with increasing strength of rocks in a wide range σ = 50–120 MPa.

It is revealed that, disk tools conical (φ = 30 °) and biconical performances (φ = 25 °+5 ° = 30 °) implement the process of destruction of large areas of maximum equivalent stress and displacement than options biconical execution (φ = 20 °+10 ° = 30 ° и φ = 15 °+15 ° = 30 °), and the minimum dimensions of zones of equivalent stresses and displacements marked for biconical execution (φ = 15 °+15 ° = 30 °). Decreased size of the zones of maximum equivalent stress and displacement on downhole the verge of a triangular prism, turned to face the third option of the knot fastening disk tool, compared with the second option, which is characterized by a higher rigidity fixing nut.

The requirements to the structures of effectors with two reverse francis crowns, the basis for the creation of which is proposed to use the complex of technical decisions on knot fastening disk tools in trihedral prisms and the results of modeling the stress-deformed state to expand the field of application roadheaders selective action of domestic and foreign production.

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Foreword

Mining technology is an important issue on resource exploitation, which is related to mine production security and energy supply. In order to promote the scientific and technological progress and international exchanges of the mining technology, the Taishan Academic Forum – Project on Mine Disaster Prevention and Control is to be held on Oct. 17-20, 2014, in Qingdao, China. The aim of the symposium is to summarize the modern coal industry achievements, in safety green mining methods and the related fields. There will be experts and scholars to attend the meeting, from the coal industry enterprises, universities, research institutions and other related fields of China and Russia.

The main topics of the symposium include: safety green mining methods, mine construction and modernization, the mining theories, methods and technology, the construction safety of mining and underground engineering, the operation and management of mining and underground engineering, etc.

The symposium is organized by the Education Department of Shandong Province, Shandong University of Science and Technology, Coal Industry Bureau of Shandong Province. It is undertaken by Institute of Mining and Safety Engineering, Shandong University of Science and Technology and State Key Laboratory of Mine Disaster Prevention and Control.

We are convinced that the symposium is going to play an important role in the development of the coal mining technology and international communication. Heartfelt thanks are extended to domestic and overseas scholars who have given great supports to this conference and all the authors who have presented the papers.

Weijia Guo, China
Yunliang Tan, China
Yongjie Yang, China
Shasha Yan, China
Dongmei Huang, China

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