Basement of Structure, Main Power and Design Parameters of Mechanism of Removing Sections of Mechanized Sets of Knife Plane Installation

N I Sysoev¹, Yu V Turuk², I Y Kolesnichenko² and B B Lugantsev²

¹ Platov South-Russian State Polytechnic University (NPI), 132, Prosveshcheniya St., Novocherkask, 346428, Russia
² Shakhty Institute (branch) of Platov Southern Russian State Polytechnic University (NPI), Lenin Square, Shakhty, 346500, Russia

E-mail: uraturuk@mail.ru

Abstract. The reasons for the failure of the pitch stability of the knife-plane installation due to the action of extreme effort in the plane of the seam from the conveyor side on the mechanism of removing sections of mechanized sets are shown. The technique for determining this effort is presented. The constructions of the adaptive mechanisms of the removing sections of mechanized sets with the basements of catamaran type, in the constrictions of which elastic elements (rods) are used, are considered. The constructions of the mechanism of removing a section of the mechanized set with the basement of catamaran type in which the stock of the hydraulic jack is connected with the band loop through the movable rods intermediate basement with a link are worked out. The intermediate basement unloads the stock of the hydraulic jack of the moving installation from the side curving efforts, caused by the action of lateral forces in the plane of the seam on the conveyor side. It increases the reliability and efficiency of work of the knife plane mechanized complex.

1. Introduction

One of the main preventing factors of introducing and efficient using the knife plane mechanized complexes of unitizing type for coal mining is the absence of specialized knife plane mechanized set in which unitizing permits one to use the mechanism of a set and for transmitting the knife plane installation to the face, to simplify the process of automatization of control both with the set and the whole complex.[1, 2].

The conditions and the nature of operation of the knife plane mechanized complex impose the following main requirements on the mechanism for moving the fastening section and moving the down hole conveyor:
- provision of directionality for moving the fastening section relatively the down hole conveyor;
- conformity of power parameters to the action of static and dynamic loads arising during the work of the knife plane.

For providing reliability of functioning the system of unitizing it is necessary that the mechanism of removing a set section should provide a definite yielding of connection with the face conveyor as well as restraining the face conveyor from slipping along the seam dipping and the directed removing of the set section [3-5].
These demands are satisfied with the constructive schemes of the mechanisms of removing, in which the pusher is fulfilled in the form of elastic rods or stabilizing devices with using hydro-chucks. But nowadays the mechanisms of removing set sections with the basements of catamaran type which would fully satisfy the demands of the knife plane technology of coal mining have not been created yet [1, 2].

2. The aim and tasks of the investigations
The aim of the work is creating the mechanism of removing a set section with the basement of catamaran type which should satisfy the demands of the knife plane technology of coal mining of higher degree. For reaching this aim, the following tasks have been solved:
- basement determining method of the extremal effort acting in the plane of the seam from the side of knife plane installation to the mechanism of removing a set section;
- constructive peculiarities of the existing mechanisms of removing shield sections of mechanized set with the basement of catamaran type have been analyzed and their disadvantages have been found out;
- the adaptive construction of the mechanism of removing the knife plane mechanized set with the basement of catamaran type has been worked out.

3. Substantiation of the method and definition of the extremal effort acting in the seam plane from the side of the knife plane installation to the mechanism of removing a set section
Successful exploitation of knife plane mechanized complexes depends to a great degree on the stability of the knife plane installation in the seam plane, i.e. on its pitch stability. The pitch stability of the knife plane installation is understood as an ability of the end stations (the keeping devices) to keep their positions under the action of the efforts, transmitted by driving organs of the knife plane and conveyor, relatively the nearby laterals, on them. The disturbance of the pitch stability of the knife panel installation is its slipping [6-8].

Provision of the pitch stability is achieved by the most accurate accounting of the forces acting on the end stations, since seventeen main regimes of work are known, under which the loss of stability may take place [10, 11].

Fig. 1 shows the scheme for calculating the extremal forces acting on the holding devices of the plowing unit.

![Figure 1. Scheme for calculating powers acting on retention mechanisms of the knife plane installations.](image)

Primary data for calculating powers are:
- \(S_1, S_2, S_4, S_{13}, S_{23}, S_{33}\) — tensions and their components appearing in the branches of the chain contour of the drive of the knife plane installation in working and extremal regime of work, N;
- \(F_1, F_2, F_3, F_4, F_{13}, F_{23}, F_{33}, F_{43}\) — tensions and their components appearing in the branches of the knife plane conveyor in working and extremal regime of work, N;
- \(F_{ur} = Q_b\) — power acting on the upper keeping device, N;
- \( F_{ur} = Q_H \) — power acting on the lower keeping device, \( H \);
- \( Q_B \) and \( Q_H \) — powers acting on the end stations of the knife plane installations through the face conveyor, \( N \).

According to the carried out analysis, the extremal (maximum) effort acting in the plane of the seam from the side of the knife plane installation on the mechanism of removing a set section at fixing the knife plane is \( F_{ur} \) — power acting on the upper keeping device.

Power \( F_{ur} \) is defined according to the expression \( F_{ur} = F_{ur}^{st} + F_{ur}^{dyn} \), N, where \( F_{ur}^{st} \) — static component of the power acting on the upper keeping device, N;
\( F_{ur}^{dyn} \) — dynamic component of the power acting on the upper retention device, N.

Calculating expressions for definition of static \( F_{ur}^{st} \) and dynamic \( F_{ur}^{dyn} \) components of the power acting on the upper retention device depend on the regime of work of the knife plane installation and are defined according to «Methods of Calculating Parameters of Knife Plane Installations» [10].

4. Analysis of constructive peculiarities of the existing mechanisms of removing and working out the construction of the adaptive mechanism of removing the mechanized set with the basement of catamaran type

As a result of the analysis of constructive peculiarities of the existing mechanisms of removing it is stated that the mechanism of removing a set section W.S. 1.7.70/150 x 1655 kN of the complex «Don-Talia 5» developed by the firm DBT (Germany) and the installation for removing a section of the mechanized set and removing the face conveyor of knife plane installation (patent of the Russian Federation №114724) satisfy the demands of knife plane coal mining [1, 2].

The installation for removing a section of a mechanized set and removing the face conveyor, consisting of a hydraulic jack, situated in the support of the hydraulic jack link, connected through the axis with the charging strainer, satisfies the demands to the knife plane coal mining in the higher degree. In this installation, the charging strainer is a link connected through the axes with rotating cylindrical draughts, situated in the skis lugs of the set section basement and two elastic rods, situated movably in the hydraulic jack support and fixed in the band loop. The stock of the hydraulic jack is pivotally connected with the band loop, which is connected with the charging part of the face conveyor.

The installation works in the following way. When moving out the stock of the hydraulic jack, situated in the support of the hydraulic jack, the band loop, interacting with the charging part of the face conveyor, transmits it to the face. At that, elastic rods, fixed in the band loop, move out from the support of hydraulic jack, unloading the stock of hydraulic jack from side curving loads and keep the conveyor of the knife plane installation from slipping along the seam dipping in the limits of their elastic deformations.

It is stated that during the disturbance of longitudinal stability of the knife plane installation to the unitizing system, i.e. the extremal effort \( Q_B \) from the side of the knife plane installation acts on the mechanism of removing the set section (Fig.2).

The extremal power \( Q_B \) action on the mechanism of removing the set section leads to the significant increase of side curving power action on the stock of the hydraulic jack and, as a result, on its curving.
Figure 2. Scheme of action of extremal effort $Q_B$ from the side of the knife plane installation on the mechanism of removing the set section.

The angle $\alpha$ between the axis AB of the hydraulic jack stock and the axis BC of the cylinder is evidence of it.

So it is reasonable to connect the hydraulic jack stock with the intermediate support, movable in the horizontal plane relatively to the rods, which is a link connected through the axis with the band loop.

In Fig.3, the supposed installation for removing a section of the mechanized set and transmitting the face conveyer of the knife plane installation is shown.

Figure 3. The installation for removing a section of the mechanized set and transmitting the face conveyer of the knife plane installation.

The proposed installation for removing a section of the mechanized set and transmitting the face conveyer of the knife plane installation consists of the hydraulic jack 1, situated in the support of the hydrojack 2, pivotally connected through the axis 3 with the charging strainer 4 which is pivotally connected through the axes 5 with the rotating cylindrical draughts 6 situated in the lugs of the skis 7 and 8 of the basement of the set section and two elastic rods 9, situated flexibly in the support of the hydraulic jack 2 and fixed in the band loop 10.

The stock 11 of the hydraulic jack 1 is pivotally connected with the intermediate support 12, flexible in the horizontal plane relatively the rods 9, which is link connected through the axis 13 with the band loop 10.

The installation works in the following way. When moving out the hydraulic jack 1, situated in the hydraulic jack support 2, the stock 11 of the hydraulic jack 1 interacts through the intermediate
support 12, pivotaly connected through the axis 13 with the band loop 10, with the charging part of
the face conveyer and transmits it to the face. At this, the elastic rods 9, fixed in the band loop 10, are
move out from the support of the hydraulic jack 2, keeping the face conveyer from slipping along the
seam dipping in the limits of elastic deformations of the rods. Elastic rods 9 flexibly situated in the
support of the hydraulic jack 2 and fixed in the band loop 10 and moving out from the support of the
hydraulic jack 2, keep the conveyer of the knife plane installation from slipping along the seam
dipping in the limits of their elastic deformations. And the intermediate support 12, movable in the
horizontal plane relatively the rods 9, together with the rods 9, unloads the stock 11 of the hydraulic
jack 1 from the side loads. At a lowered section of the set, loading the hydraulic jack 1, removing the
set section, takes place. At this, the support of the hydraulic jack 2 with the hydraulic jack 1, moving
along the elastic rods 9, interacting with the charging strainer 4, rotating cylindrical draughts 6 and
ski 7 and 8 of the basement removes the set section. The two elastic rods 9, fixed in the band loop 10,
connected with the charging part of the conveyer of the knife plane installation, provide the directed
removal of the set section.

The charging strainer 4, pivotaly connected with the rotating cylindrical draughts 6, provides
longitudinal transmission of the ski 7 and 8 of the set support relatively each other. And rotating
cylindrical draughts 6, situated in the ski of the support 7 and 8 of the set section of the mechanized
set, provide their transmission in the vertical direction during overcoming «the thresholds» in the seam
ground by the set section.

The design parameters of elastic roads 9 (their diameter and length) are chosen taking into account
the action of the extreme force Q₆ from the side of the knife plane installations on the mechanism of
the movement of the set support.

5. Conclusion
1. The method of determining the extremal effort acting in the seam plane from the side of the knife
plane installation on the mechanism of removing a set section was substantiated.

2. The structural layout of the mechanism of removing a section of the mechanized set with the
support of catamaran type was developed. In this section, the stock of the hydraulic jack is pivotaly
connected with the band loop through the intermediate support, which is movable in the horizontal
plane relatively the rods. Such connection unloads the stock of the hydraulic jack of removing from
the side curving efforts, thereby increasing the reliability and efficiency of operation of the knife plane
mechanized complex.

References
[1] Sysoev NI, Turuk YuV 2013 Basing elastic elements usage in the construction of the mechanism of
moving the shield plane section of the mechanized set with the basement of catamaran type Modern
problems of science and education
[2] Sysoev NI, Kolesnichenko IY, Turuk YuV 2014 Basing rod pushers usage in the mechanism of
removing the shield plane section of the set with solid basement Modern problems of science and education
[3] Schumacher FP, Kim E 2013 Modeling the pipe umbrella roof support system in a Western US
underground coal mine International Journal of Rock Mechanics and Mining Science
[4] Gong P, Jin Z 2008 Mechanical model study on roof control for fully-mechanized coal face
with large mining height [J] Chinese Journal of Rock Mechanics and Engineering
[5] Juan YK, Gao P, Wang J 2010 A hybrid decision support system for sustainable office building
renovation and energy performance improvement Energy and buildings
[6] Du B, Chen H 2006 Similar Simulation Study on Abutment Pressure Distribution at Close-
Distance Seams [J] Journal of Henan Polytechnic University (Natural Science) (en.cnki.com.cn).
[7] Ma Z, Gong P, Fan J, Geng M, Zhang G 2011 Coupling mechanism of roof and supporting wall
in gob-side entry retaining in fully-mechanized mining with gangue backfilling Mining Science and
Technology
[8] Yang S, Zhang J, Chen Y, Song Z 2016 Effect of upward angle on the drawing mechanism in longwall top-coal caving mining *Journal of Rock Mechanics and Mining*

[9] Song G, Chugh YP, Wang J 2017 A numerical modelling study of longwall face stability in mining thick coal seams in China *International Journal of Mining and Mineral Engineering* (inderscienceonline.com)

[10] Lugantsev BB, Osherov BA, Averkin AN 2010 The method of calculation of parameters of plows (Novocherkask: “Lik”) p 135

[11] Kumar BR, Sankar US 2011 Selection of powered roof supports–2-leg shields vis-à-vis 4-leg chock shields *VNS Prasad -academia.edu*