Improvement of loading and transport bodies of tunneling machines

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Abstract. The article discusses the use of sets of equipment for mining and construction of road tunnels with the use of a self-propelled vehicle and bunker loaders to transport the mined rock. A patented design of the tunneling combine loading body, which allows adjusting its performance and power consumption in the loading mode, is considered. Reducing stress in extreme situations will make it possible to avoid overloading the drive and increase the reliability of the combine as a whole. The scheme of one of the most promising variants of the wedge bunker loader with variable geometry of the conveying elements is presented. The proposed design solves the problem of "locking" the material in narrow parts of the conveying body or in places where loading and transport bodies of different width are connected, as well as in the blast-and-heap mode of the loader.

1. Introduction

One of the main tasks one faces when choosing the transport vehicles for carrying out excavations including driving transport tunnels is compliance of their loading and transporting capacity with the set productivity of the driving combine or the loader. At the same time the design of the vehicle has to correspond in geometrical parameters to the cross section of the development.

When driving is fulfilled by combines, self-propelled transport is widely applied [1, 2]. The standard set of the driving equipment consists of a combine of selective action, a bunker loader with a ground scraper conveyor and a self-propelled pneumatic tire car transporting mined rock from the bottomhole zone to the main transport. Mined rock from the combine accumulates in the bunker loader while the car goes to the place of unloading and backwards. The need and expediency of transition to the scheme of transportation of material different from by tape and scraper loaders are in detail justified in sources [3, 4].

2. Loading bodies of tunneling combine

Freight flow of mined rock when carrying out a development begins with the loading body of the driving combine. The combines released by the Russian industry of KP200T, KP21-150, KP220, 1GPKS type are equipped with the loading bodies executed in the form of spiders of various design [5]. By request of the consumer the combine can be equipped with a loading body with additional expanders allowing to increase the front of loading.

The loading body of combines has separate, kinematically not connected, hydraulic drives and control for each shovel element. A number of conducted investigations [6, 7], reveal the following
shortcomings of such loading bodies.

Shovel spiders while in operation form portion freight traffic of material, their productivity depending on their sizes, the speed of their rotation and the pattern of filling the working zone between their legs with material. The power-hungriness of the process of loading is proportional to the volume of the material loaded and density of mined rock. When rock mass of higher density or larger volume is loaded, the power consumption can considerably rise, that leads to overload of the drive of the loading body and the combine as a whole. As a result, reliability of operation of the tunneling machine decreases.

The solution allowing one to eliminate the specified defects, namely, to increase reliability of the combine by means of regulating efficiency of loading is found.

The developed loading body (Figure 1) contains a feeder 1, a reception conveyor 2 located on the axis of the feeder below the feeder level, shovel spiders 3 with shovel legs 4, cover disks 5 resting on the feeder and protecting the rotation mechanism from the ingress of the material loaded. Arrows in figure 1 indicate the directions of the motion of the shovel elements.

The specified technical effect is reached by the ability of spiders to move in axial direction relative to the axis of their rotation through the openings in the cover disks. The proposed design of the loading body allows to adjust the height of legs over a cover disk, and, as a result, regulate capturing capacity of the shovel spiders, efficiency and power consumption of the loading process.

![Figure 1. Loading body of the tunneling combine.](image)

The loading body operates as follows. The shovel spiders 3 rotating, material is captured by spider legs 4 and transported to the axis of the feeder 1 where it is droped and transported by the receiving conveyor 2. To reduce loading capacity of the spider, it is sunk relative to cover disk 5, for the increase it is moved in the opposite direction.

3. Analysis of designs of loading and transport bodies

The following and the last link of freight flow in the bottomhole zone is the bunker loader. At the Shakhty Institute (branch) of Platov South-Russian State Polytechnic University (NPI) the bunker loaders with changeable height of the wedge transporting elements and forward action hydraulic drive are developed [8]. Reliability and efficiency of application of wedge elements in loading and transport bodies of tunneling cars, especially when loading and transporting lump bulks, is justified in sources [9, 10]. The general view of a bunker loader, suggested for use as a part of equipment set for the construction of automobile tunnels is given in Figure 2 [8].
One of the problems arising in further development and improvement of technological schemes, as well as in the choice of rational sets of the tunneling equipment is transfer of the loaded material from the bunker onto the narrow, in relation to the bunker (its width), loader. A similar problem arises in some cases when updating loaders. A number of technical solutions for loading and transport bodies of tunneling cars with wedge shovel and transporting elements are known so far [11-13]. The analysis of their design allowed one to establish the reasons of their inadequate efficiency:

- locking of material in a tray when pushing through between a shovel element and a loader;
- reverse freight traffic of material caused by back and forth motions of the transporting elements;
- application of the additional units of material supply leading to increase in length of the car and decrease in reliability;
- complexity of mechanical units that control change of height of the transporting elements, and others.

4. Results
After conducted studies of the lead-tin-base bronze structure of the BrO10S10 grade, it is possible to For the purpose of elimination of the specified shortcomings and the increase in efficiency of loading mined rock, a technical solution has been proposed (Figure 3). It allows one, firstly, to fulfill transfer of material from wider "front of loading" to the conveyor of narrower width without additional devices, and, secondly, to exclude from the design the unit of supply of material from a wedge shovel nose to the transfer conveyor, reducing thereby the length of the loading body.

The developed loading body consists of a feeder 1 of trapezoid form with flanges 2, a wedge shovel nose 3 which, in turn, includes several (in this case - two) wedge shovel elements 4 and 5, one of which is placed in the case of another, with a possibility of movement in relation to each other. Wedge elements 4 and 5 are kinematically connected to power hydraulic cylinders 6 by means of the sliders 7 placed in grooves made in flanges 2 of feeder 1. In the narrow part of the loading body the transfer conveyor 8 is located.
Figure 3. Loading body.

The loading body works as follows. Before loading the feeder 1 is located in a stack of lump bulk. Activated by power hydraulic cylinders 6, by means of sliders 7, wedge shovel nose 3 moves inside the stack of the loaded material in the direction from the transfer conveyor to a forward edge of the feeder with simultaneous oversleeping of bulk over it. At the same time wedge elements 4 and 5 perform a complex movement: joint, along the feeder towards the stack as a single shovel nose, and in relation to each other (element 4 leaves element 5). At full advancement of rods of power hydraulic cylinders 6 and, accordingly of the wedge nose, its width in the cross section of the feeder 1 reaches the maximum value.

In the course of retraction of rods of power hydraulic cylinders 6, the wedge shovel nose 3 moves in the direction of the transfer conveyor 8, simultaneously pushing a portion of the loaded material through to the conveyor. Wedge elements make the movement in relation to each other (element 4 enters element 5) and move towards the conveyor 8 as a single shovel nose 3. At completely retracted rods of cylinders 6 and, respectively, in the extreme back position of the wedge shovel nose, the latter reaches its minimum width in the cross section of the feeder.

Thus, the whole portion of the loaded material moves from a forward edge of the feeder 1 to the transfer conveyor 8 without any additional units of material supply.

5. Conclusion
The application of the technical solutions of loading and transport bodies presented in the article will allow increasing overall performance of tunneling cars. The patent for the invention RU 2584071 has been granted for the offered design of the working body of the tunneling combine. As for the developed design of the bunker loader, the decision on issue of the patent for the invention has been obtained.
The executed pilot studies of loading and transport bodies allowed one to set their rational parameters and form the basis for the design of prototypes. Currently, work on their production is underway and research on expansion of their functionality is carried out.

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