The use of upgraded hopper cars in the mining industry

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S u m m a r y. The process of transporting the roche to the dump and formation of a flat rock dump in the coal mining industry is concerned. The use of railway rolling stock in order to reduce the cost of transportation of bulk cargo in the surface mining. Prospects for the use of upgraded hopper cars with one-sided self-discharge (on one side of the railway).
K e y w o r d s. transportation, rock, roche, dump, hopper car, self-unloader, expenses.

INTRODUCTION

Undeniable trend in the global mining industry development in the foreseeable future is a stable orientation to the open-cut mining method, providing the best economic performance. It falls to share up to 73% of the total volume of production of natural resources in the world (in the U.S. - 83%, in the CIS countries - about 70%). The development and improvement of open-cut transport are the main for open-cut mining.

It is known that the development of the open-cut mining method is accompanied by increasing concentration of production, increasing the depth and the spatial dimensions of pits, and the distance of transportation of rock [Melnikov, Reshetnyak 1994].

Coal industry companies transportation is a complex system of interconnected transport links, located as within the company and outside it. The smooth operation of all links of the process of the enterprise depends on precise organization of the transport process. Great importance in transportation acquires not only the reliability and efficiency of its use, but also the cost of equipment, materials and resources. The task of transport in the mining industry is to deliver a total volume of coal from the mine to the point of destination, to export rocks to dump and transport of materials with maximum speed, minimum cost and with the traffic safety.

Thus, we can identify the main directions of development of transport in the coal industry: the modernization of the rolling stock, resources, cost reduction of the coal produced in the enterprise [Yakovlev, Vityazev 2004]. It is known that more than half the cost of coal is the cost of its transportation to the destination and transport of rock in the dump. Consequently, at present reducing the cost of transporting waste rock to the dump of the mine is a very urgent task.

OBJECTS AND PROBLEMS

Increased attention to coal mining industrial transport in most countries, the search for ways to reduce the significant transport costs inside industry traffic and sharp increase in the volume of scientific and research work in this area led to significant changes in the development of technical equipment and industrial transport in the coal mining industry. In recent years, an intensive search for new ways to develop the most appropriate transport for the coal industry, which is used to handle the roche and form the dump [Anistratov 2011].

Modern vehicles for roche handling should be easy to use and powerful. Currently, about 80% of the rock is transported by road, due to the possibility to travel long climbs in operation in open mining. The main limitation of the use of road transport in the mining industry continues to be a high cost of transportation of the rock mass [Kulichkin, Konopelko, Biryukov 2011, Parunakyan V.E., Artamonova Y.V., 2007]. In addition, open-cut mining road transport is a major source of negative human impact on the environment in open cast mining and handling the rock to dump. Share of the cost for transporting rocks reaches 40% of the total cost of the work in the quarry or mine, so this problem of the current world requires special attention [Popov, Kaplunov 2010, Yakovlev, Vityazev 2004, Baron 2009, Pomazkov 2010].

Under present conditions in the largest iron ore, coal and asbestos quarries in the CIS countries one of the major technological transport of the industry is railway [Yakovlev, Bahturin, Stolyarov 2002, Parunakyan 1966]. Longstanding experience using the electrified rail in deep pits shows its high performance when used in preferred mining conditions of operation [Yakovlev, Vityazev 2004]. Analysis of the scientific, technical and design solutions allows us to state that in the future as for the existing as for the newly developed deposits the electrified railway will remain one of the principal modes of transport. The main advantages of electrified railway are the following [Yakovlev, Popov, Kotyashev, Kosnarev 2002]:

- higher average running coefficient of efficiency;
- cost effectiveness (relatively low prime cost of transportation of rocks) and operational reliability;
- the possibility of a significant overload of electric locomotives;
- easy to operate and maintain.

All these advantages are the result of the centralized electric energy supply. It should, however, be noted that the centralized energy supply requires a fairly large infrastructure (traction substations, contact networks, etc.) that, the high cost of locomotives and large volumes of runaway pit to accommodate the communications cause the high capital intensity of rail transport. Important benefits of electrified rail transport are also saving non-renewable liquid fuel, the almost complete absence of exhaust gas pollution, a small dependence on climatic conditions.

As noted in [Gubacheva, Andreєv, Ryabtseva 2009, Debelle 2006, Parunakyan., Lozynskyy 1962, Parunakyan, Yasyuchenya 1962] been based on the availability of narrow-gauge railway transport infrastructure in the mines the mine electric locomotives have been widely used to maintain the mines, quarries and rock transportation.

The main disadvantage of rail transport is relatively low average of longitudinal slope of the road. The main directions of development and improvement of rail transport is increasing the road slope to 60 - 80% [Golubenko Gubacheva, Andreev 2009, 2010, Yakovlev, Fesenko, Neugodnikov 2001].

Train sets for rocks transportation are dumping cars, side-dumping cars [Parunakyan, Sinianskaya 1969, Parunakyan, Yasyuchenia 1960]. However, the use of the rolling stock is not effective due to the high level of metal consumption, complexity and design of the car body tilting mechanism, the necessity of much effort to self-discharge, significant deterioration of all its parts.

Thus, the aim of this work is to reduce the cost of handling the rock to the dump, formation of a flat waste dump in the mining industry.

A special role in solving this problem belongs to the creation of new designs of specialized wagons for transportation the bulk cargoes.

When you create a specialized self-unloading wagons of new generation for bulk cargo (rock) is an extremely important problem of improving the choice of rational parameters of the type of cars that are in the early stages of their design will identify promising options for car design and individual functional units [Savushkin 2003]. This paper proposes the creation of a new generation of rolling stock for transportation of bulk cargoes - upgraded hopper car with a one-sided self-discharge (on one side of the railway).

The main feature of the hopper cars is their ability to self-discharge. This attribute determines the conceptual scheme of constructive discharge device and a corpse of bunker wagon. Choice of rational parameters of unloading hopper car defines one of the most important for this type of car commercial indicators, which is easy to end operations.

Hopper-car open model 20-40-15 for transportation of hot pellets and sinter is known [Kuzmich 1978]. The car design provides a mechanized loading through an open body and automatic unloading of the two sides of the railway line through the two side door. The car is equipped with unloading pneumatic mechanism and automatic locking system to ensure reliable locking of manhole covers and automate the unloading process. Open hopper has a remote automated unloading of cargo on both sides of the railway track, driven by compressed air from the power plant of the locomotive.

Essential disadvantage of hopper car is incomplete self-discharge of bulk cargo, which requires additional manual unloading, and the impossibility of mechanized forming single flat blade of bulk cargo when unloading.

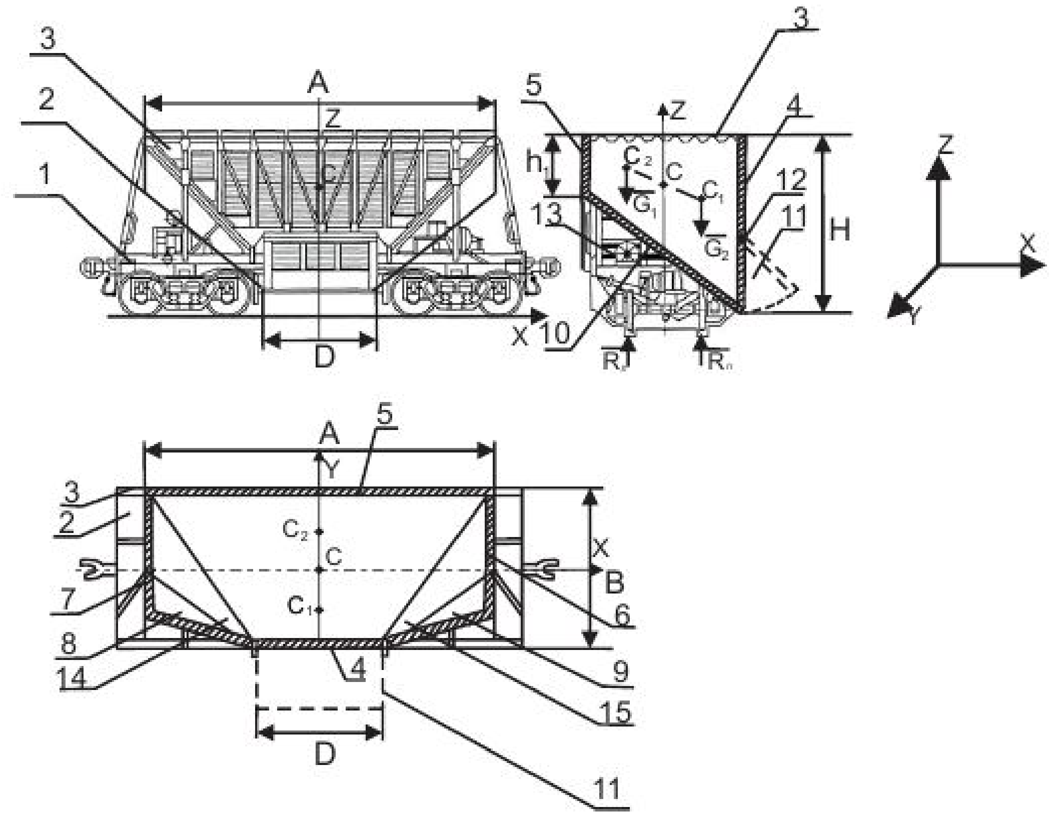

Fig.1. Hopper car with a one-sided self-discharge

The studies have shown that to ensure a complete unloading of bulk cargo on the right side of the railway track on relative motion of the car is possible by improving the known hopper car with a constructive change of body shape (fig. 1).

Figure 1. shows a hopper car front view, top view and side view [Gubacheva, Andreev, Leonova 2012]. . Hopper car includes a frame 1, carcass 2, metal body 3, consisting of the side walls 4 and 5, the end walls 6 and 7, the transition walls 8, 9 and 14, 15, part of the side wall is transformed into the floor 10 of the body, unloading equipment as inclined to bottom of the hatch with cover 11 attached to the hinge 12 to the side wall 4 and the linkage 13 with pneumatic cylinders for opening, closing and locking cap 11, the upper part of the cross section of the bunker in the plan looks like joined up large bases along the longitudinal axis of the rectangle and trapezoid with lateral transition parties and the small base on the discharge side of the side wall.

Transitional walls 8, 9, and 14, 15 provide the increase of body useful volume and improvement of indexes of hopper car load through an open body.

In a hopper car one discharge hatch with a cover hanging on the front hinged vertical side wall of the discharge is preserved, and all other walls are made obliquely.

In the place of dump formation the unloading cover of the hopper car, hanged in the hinges to the side wall, using the lever mechanism with driven pneumatic cylinders, opens and under the load own weight self-discharge is carried out through a hatch hopper car on one side of the railway track (on the right side with respect to the movement).

In terms of rail transport operation in the mining industry it is important to ensure the sustainability of the rolling stock and safety [Gorbunov, Kostyukevich, Kravchenko, Kovtanets 2011, Basov, Kireev, Lysak 2010].

The hardness and safety of upgraded hopper car motions (fig. 1) is achieved with the permanent coincidence of the mass center C of bulk cargo at full unloading with a central vertical axis of the body. This is provided by asymmetrical bunker of a hopper car subjected to the equilibrium points of the weight G_1 of the right side cargo and G2 of the left side cargo full bunker with the relative to the center C. Herein the conditions for the transfer of the same load from the static forces on all eight wheels is created that helps to improve the technical characteristics in the process of movement and self-discharge.

To calculate the weighing of cargo and the time of unloading, the cargo bay of the hopper car is broken into four parts (upper, middle, and two of the end) [Gubacheva, Andreev, Leonova 2012]. After determining the geometric characteristics of the components of the body load compartment the dependences was found. It identifies the rational size to transport different types of cargo:

- height of the body back wall h_1:

$$h_1 = H\frac{(A+7D)}{(9A-D)}, \qquad (1),$$

where: A and B are the length and width of the cargo hold, respectively;

D - discharge gate width;

H - the height of the front side of the cargo bay.

- obliquing angle α of the main rolling down surface (at H ≈ B):

$$tg\alpha = \frac{H-h_1}{B} \qquad (2),$$

- the volume of cargo compartment taking into account the dimension of the rolling stock and transitional walls that increase the usable volume of the hopper car:

$$V = 0{,}28B\left[A(H+2h_1)+DH\right] \qquad (3)$$

Having studied the process of cargo unloading from the body of the upgraded car it was found that its efficiency depends on the width of the discharge gate D. That allowed to get the dependences (fig. 2) of the hopper unloading time Tp = $f_1(\frac{D}{A})$, obliquing angle of the main rolling down surface $tg\alpha$ = $f_2(\frac{D}{A})$, total cargo compartment capacity V = $f_3(\frac{D}{A})$ on the width of the discharge gate.

Analysis of the dependences showed, that additional transitional walls provide increase the useful volume of the car body, change in time of unloading, which in its turn depends on the obliquing angle of the rolling down surface and simplifies the process of loading the hopper car ensuring the sustainability of the rolling stock moving in the rail track.

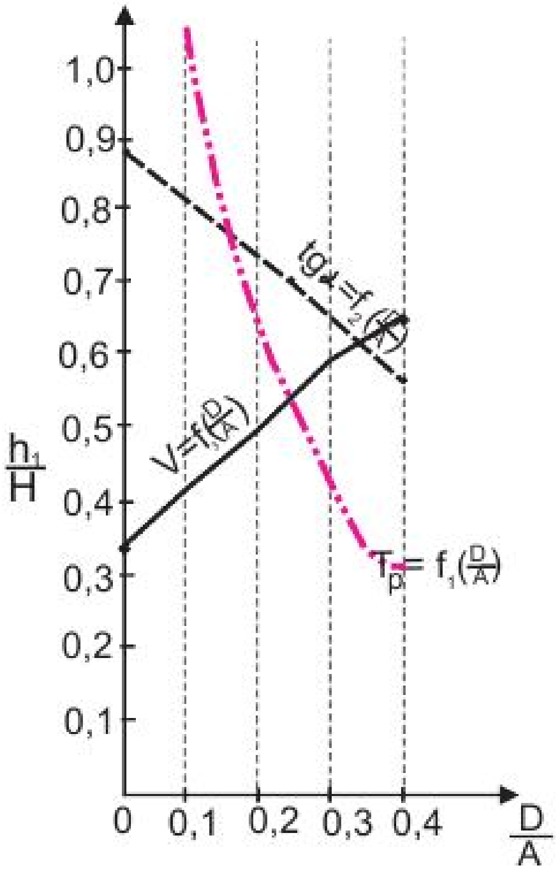

Fig. 2. Dependence of the time discharge hopper $T_p = f_1(\frac{D}{A})$, on the angle of the main roll off surface $tg\alpha = f_2(\frac{D}{A})$, general cargo capacity $V = f_3(\frac{D}{A})$ on the width of the discharge gate.

CONCLUSIONS

The use of the upgraded hopper car with a modified asymmetric body design in the mining industry will facilitate the process of transportation of rock and formation of the dump, reduce transportation costs (on 10%) and therefore reduce the prime cost of the coal produced in the enterprise.

On the basis of the achieved dependencies it is possible to select the required size of the car body to transport a particular type of cargo in various industries.

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ИСПОЛЬЗОВАНИЕ МОДЕРНИЗИРОВАННЫХ ВАГОНОВ-ХОППЕРОВ В ДОБЫВАЮЩЕЙ ПРОМЫШЛЕННОСТИ

Лариса Губачева, Александр Андреев, Светлана Леонова

Аннотация. Рассмотрен процесс транспортирования горной породы в отвал и формирование плоского породного отвала в угледобывающей промышленности. Применение железнодорожного подвижного состава с целью снижения затрат на перевозку сыпучих грузов на открытых горных разработках. Перспективы использования модернизированных вагонов-хопперов с односторонней саморазгрузкой (по одну сторону от железнодорожного пути).

Ключевые слова: транспортирование, порода, отвал, вагон-хоппер, саморазгрузка, затраты.