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Longwall shearer haulage systems – a historical review. Part 3 – Chainless haulage systems with drive wheel and rack bar

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Abstract:

Chainless shearer haulage systems with rack bar are currently the most popular group of this kind of solution. The first type of rack bar was captivated chain. In 70-ties great number of different solution of chainless haulage systems with drive wheel (sprocket or pin) and different rack bars were implemented. Afterwords some of them were abandoned for different reasons, but some are still in duty and under improvement. This article is the third and the last part of shearer haulage systems technical review, concentrated on chainless haulage system. Beginning from the british Rollrack with pin drive wheel and toothed rack bar through similar solutions with sprocket drive wheel in Europe and China and solutions with vertical or horizontal ladder type of rack bar is reflect technical development of shearer haulage system till contemporary solutions and trials of improvement.

Keywords: longwall mining, longwall system, coal cutter-loader, coal shearer, shearer haulage system, cordless haulage systems, chainless haulage systems

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1. Introduction

In modern mechanized longwall systems with shearer loaders, chainless haulage systems are applied, almost exclusively especially those based on the idea of a toothed rack bar a solution developed in the 1970s by Eickhoff in the form of a horizontal "ladder", i.e. a double bar connected by means of profiled pins (crossbars). However, before theEickotrack and solutions based on its idea mastered the mechanized longwall systems, a number of other solutions had been developed, which became popular over time and gradually lapsed after some better solutions became widespread.

2. Haulage systems with drive wheel and rack bar.

Fig. 1 shows the basic groups of technical solutions of the chainless shearer haulage systems with a drive wheel captured with profiled tracks.

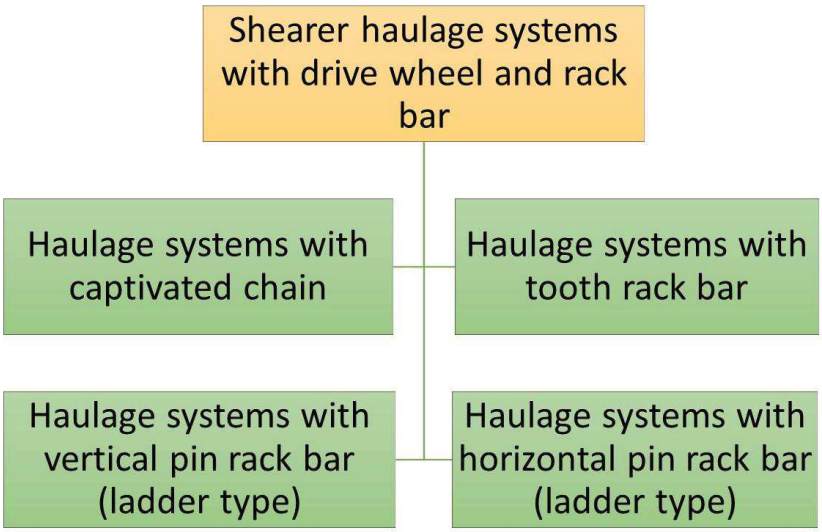

Fig. 1. Typology of the shearer haulage systems with drive wheel and rack bar

The captivated chain systems were discussed in the previous article [1].

At the beginning of the search for solutions for the shearer haulage systems with a drive wheel and a rack bar, the idea interfering to as less as possible extent with the shearer carriage's structure was dominant. This was due to the search for solutions that could be applied in already operating shearers [2,3].

3. Haulage systems with toothed rackbar

The first haulage systems with a drive wheel and a toothed bar were developed in Great Britain [4, 4,5]. in the mid-1970s.

3.1. Rollrack haulage system

First haulage system with toothed rackbar was the british Rollrack. In this system, the "teeth" were placed on a special structure of the armoured' face conveyor's spill plate on which the driving wheel of the longwall shearer was rolling. The vertical wheel (with a horizontal axis of rotation) was doubled with pins (Fig. 2).

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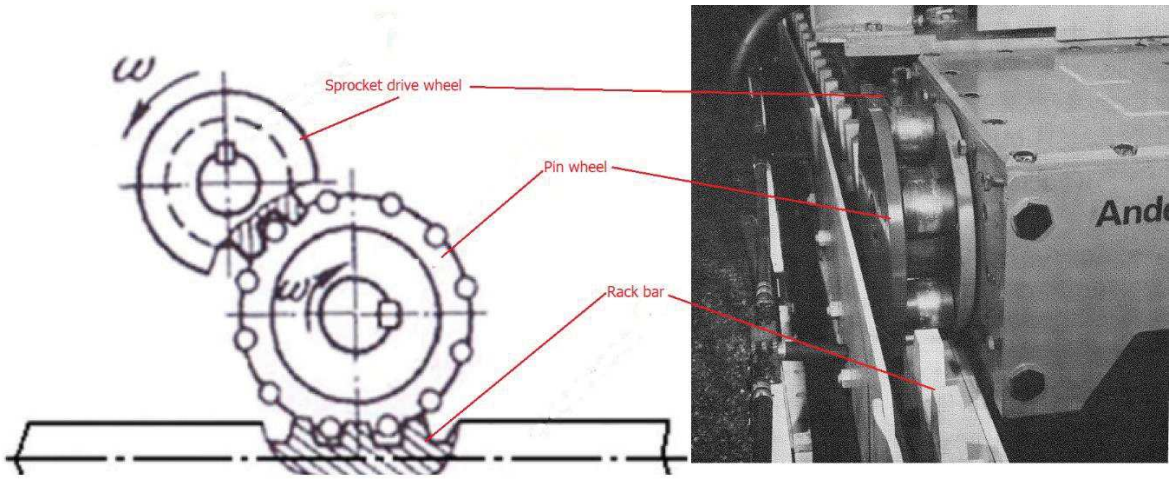

Fig. 2. Idea of the Rollrack chainless haulage system

The disadvantage of the original solution was the lack of forced guidance of the longwall shearer and thus the possibility of the wheel falling out of the toothed bar - it eliminated the possibility of using this solution in inclined or folded longwall faces, but in the case of British mines it was not a problem.

On the basis of operational experience, a trapping shoe was implemented afterwards to prevent the drive wheel from falling out of the toothed bar, thus extending the scope of application of the shearers with this haulage system (Fig. 3), including folded longwalls and walls with a greater inclination gradient (slope).

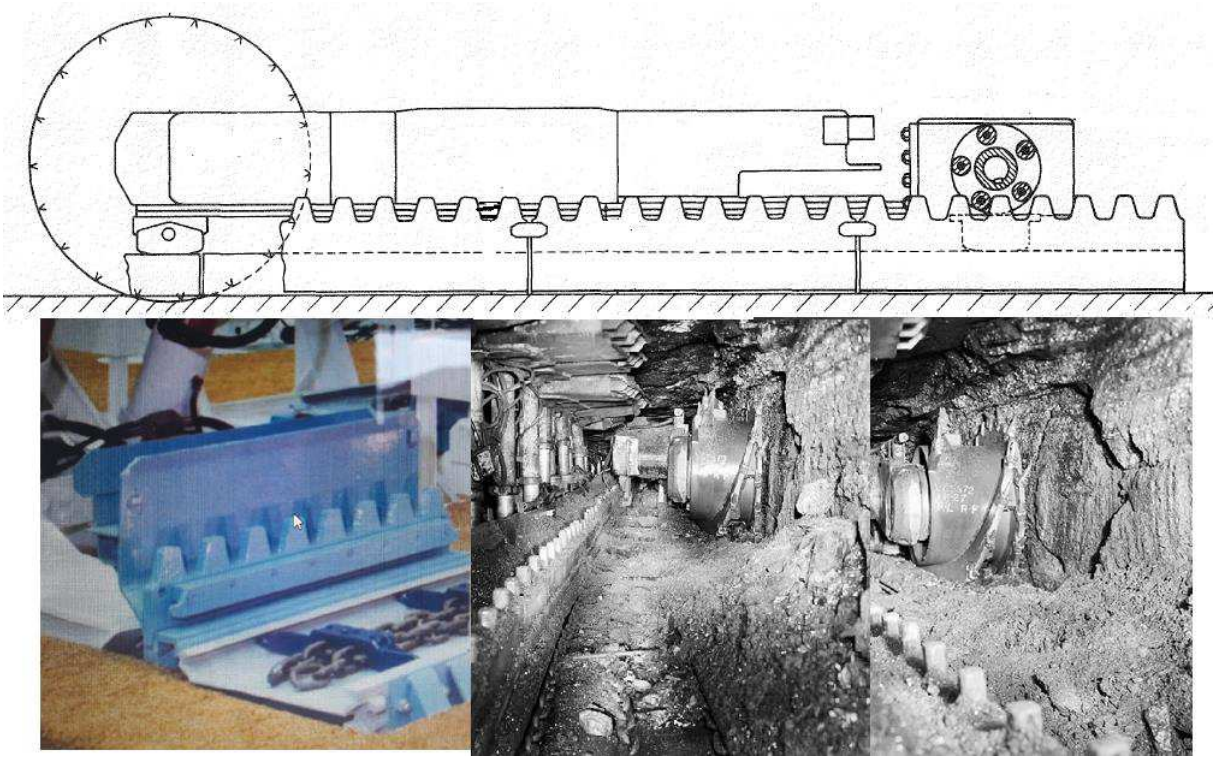

Fig. 3. The Rollrack chainless shearer haulage system

The Rollrack system was widely used in the British mining industry, and this solution was still offered in the 90s of the last century. The Rollrack haulage systems were also used in British double-drum shearers, including those with ranging arms [6].

The idea of shearer haulage systems with a rack bar and a drive wheel (with transverse pins or profiled toothed drive wheel) was later applied in various variations described below.

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3.2. The Saartrack system

A haulage system with a profiled toothed bar attached to the armoured face conveyor pan route was developed in the German Saar Basin (Fig. 4) [7].

Fig. 4. The Saartrack chainless haulage system [7]

The structural complexity of the Saartrack haulage system and the high manufacturing costs prevented this haulage system from becoming widespread. This system was very sensitive to changes in the longitudinal inclination in the longwall, which was its additional constraint. In addition, a high sensitivity to the horizontal bending of the AFC route (e.g. during advancing) occurred in this solution.

3.3. Toothed rack bar systems in Poland

In the 1980s, attempts were made to develop an effective shearer loader intended for low walls in the Polish coal mining industry. The first to be developed were shearer loaders with external chain haulage drives with forced "endless" chain guidance and control of the haulage system by means of a frequency converter (KGS150, KGS200).

Based on the experience with these shearers, a new generation of shearers was later developed with electric, chainless haulage system with a toothed bar placed on the armoured conveyor from the coal face side (Fig. 5). The cast toothed bar, forming a whole with the toe (runway) was screwed to the side profile of the AFC pan [8,9,10]

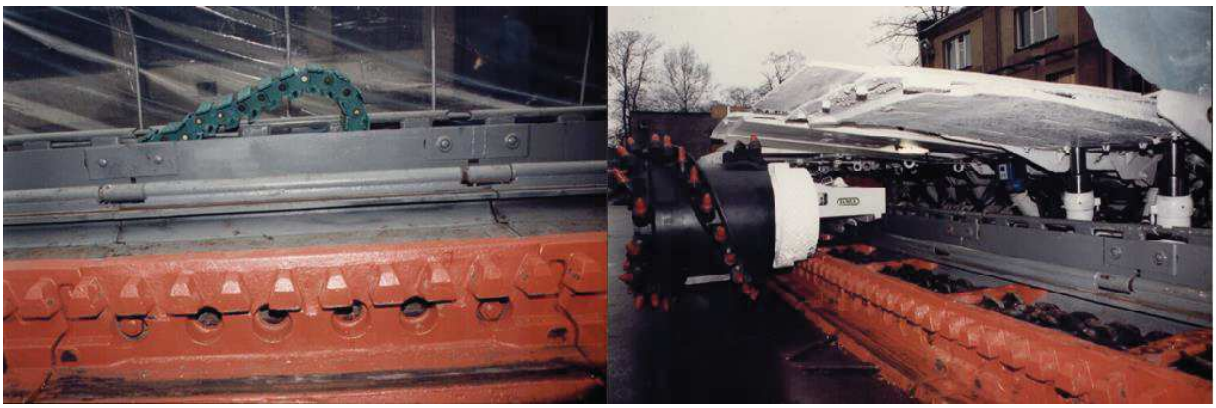

Fig. 5. The KSE-360 Polish shearer with chainless haulage system along the toothed rackbar embedded on the armoured face conveyor from the coal face side

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The KSE-344 shearers with such a feed system were applied, several of which worked in the Polish hard coal mines (i.a. Dębieńsko, Gliwice, Bolesław Śmiały). In 1997 as part of the work on a new longwall system for low coal seams, a prototype of the KSE-360 shearer (FAMUR S.A.) with this feed system was developed and manufactured. It was tested at the Dębieńsko mine. A similar solution had been previously developed by Eickhoff.

3.4. Chinese solutions.

Haulage systems with a toothed bar and a toothed drive wheel for low walls were also developed in China [11], where various solutions were created (mainly for low walls), such as:

- System with a vertical toothed bar from the coal face (Fig. 6)

Fig. 6. Haulage system of a low longwall shearer with a vertical toothed rack from the coal wall side [11]

This solution made it difficult to load the excavated material onto the armoured face conveyor, although its main part was loaded over the shearer arm.

- To improve the uniformity of the haulage system operation, double toothed bars with the mutual offset (shift) of the teeth by ½ pitch and the drive wheels with a similar phase displacement (shift) of the teeth were implemented. Such solutions were used with vertically (Fig. 7) and horizontally positioned teeth of the rack.

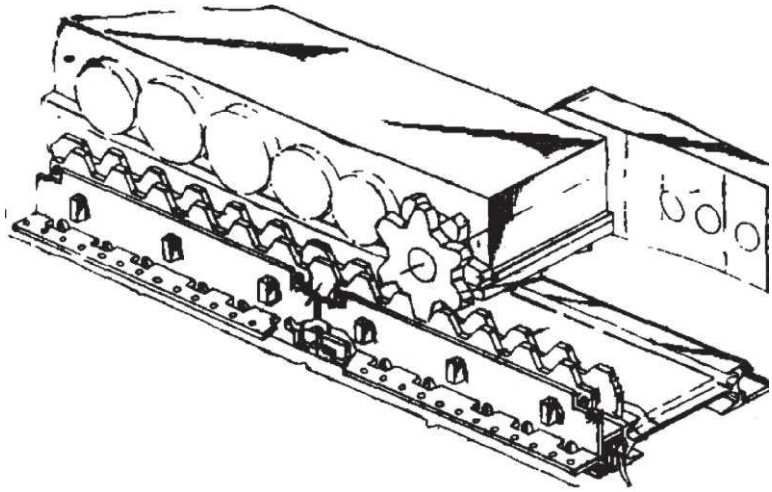

Fig. 7. Chainless shearer haulage system with double vertical toothed rack [11]

A similar solution with a double horizontal toothed rack (Fig. 8) applied to low coal shearers significantly limited the clearance between the armoured face conveyor and the longwall shearer.

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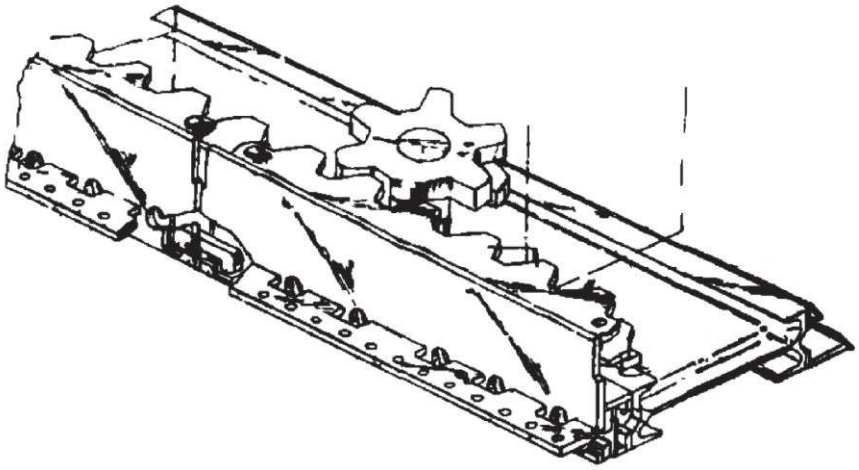

Fig. 8. Chinese chainless shearer haulage system with double horizontal toothed bar [11]

Any experiences with this system are not known.

3.5. Contemporary systems with toothed bar.

Nowadays, chainless feed systems with a drive wheel and toothed bar are still rarely encountered.

As an example, in 2021 a solution of this type was provided to one of the Ukrainian mines by the Corum Group (Fig. 9] [12].

Fig. 9. The CLS550P shearer loader with electric haulage system with a toothed bar on the dedicated armoured face conveyor SPC271M from the coal face side [12]

This complex is intended for the exploitation of walls with a height from 0.85 m. The cast toothed rbar forms a whole with the runway (toe) fastened to the AFC pan route (similarly to the Polish KSE344 and KSE360 shearer loaders - Fig. 5)

4. Haulage systems with vertical rackbar.

Haulage systems with a vertically positioned ladder bar were implemented in the mid-1970s, first in British mines, and then in Poland.

4.1. Pin/Wheel haulage systems

Development and implementation of longwall shearer haulage systems with vertical pin rack bar ladder was initiated by the National Coal Board in the mines of the southern part of County of Nottingham, where this haulage system with a hydraulic drive was applied (Fig. 10) [2].

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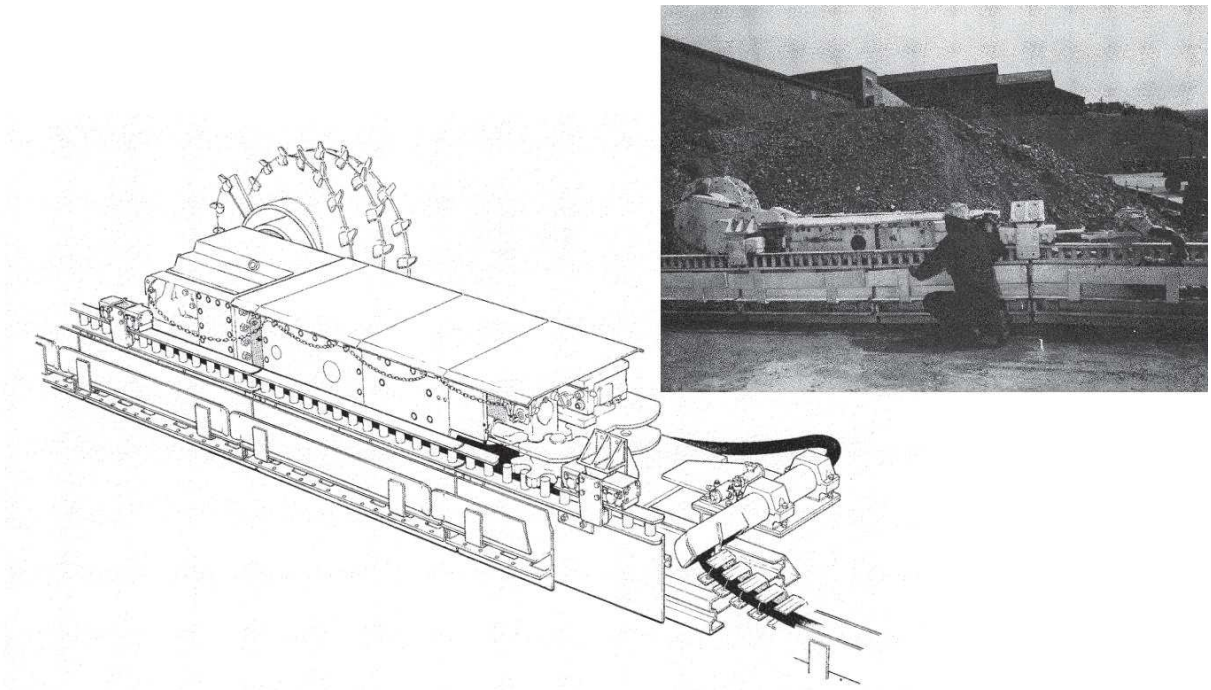

Fig. 10. Chainless haulage system Pin/Wheel with vertical pin rack bar (ladder type) developed in the National Coal Board (NCB) [2]

The idea of this solution was to fasten a vertical ladder composed of two flat bars connected by pins to the armoured conveyor's spill plate. The length of the ladder segment was the same as the length of the face conveyor pans. The horizontal drive wheel rotations resulted in the shearer moving along the face. In flat walls, where there were no changes in the transverse and longitudinal slope, this solution worked properly, and therefore already in 1977 in British mines there were 14 longwall shearers equipped with such haulage systems. The presented haulage system revealed its disadvantages when used in longwalls with varying transverse and longitudinal slopes. At the bends of the floor, the longwalls operating relatively high above the floor became damaged or the drive wheels were damaged due to a change in the pitch of the crossbars/pins at the links/joints. These problems escalated with increasing force and haulage speed. For this reason, this solution was abandoned quite quickly, especially since more forward-looking solutions were already available.

4.2. Polish haulage system Poltrak II

In the Polish underground hard coal mining, which was very modern at the turn of the 1970s and 1980s, problems and threats related to the longwall shearers' chain haulage systems, occurred with great intensity. Moreover, for economic and political reasons, an access to many technical solutions developed in the most advanced countries of Western Europe was difficult. An additional problem was the fact that the Polish coal mining exploited mechanized longwall systems in a range of conditions wider than elsewhere, especially inclined ones and in geological disturbances. In longwall faces with greater longitudinal slopes, it was necessary to prevent the shearer with a chain haulage from sliding down in the event of a chain break. Under these conditions, the work was undertaken on the Polish chainless haulage system, using the idea of a vertical pin rac kbar ladder type. The first solutions similar to the pin/wheel system were tested in mines to finally develop the Poltrak II system eliminating the disadvantages of the British solution [9,13,14].

The idea of the Poltrak-II solution consisted in using a vertical pin rack bar ladder type, which was not rigidly attached to the AFC spill plate. The rack bar ladder was connected to the conveyor by means of rigid strands with flexible connecting joints/links (Fig. 11)

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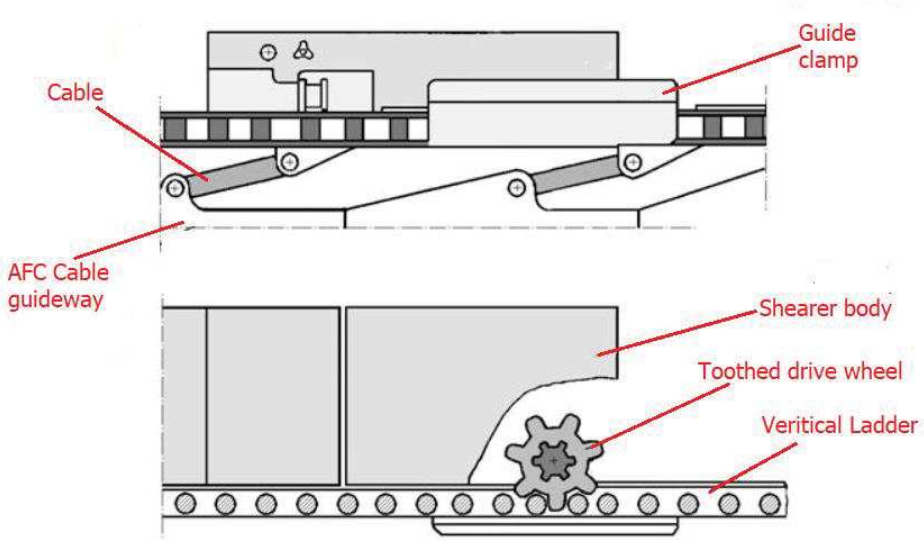

Fig. 11. Polish chainless haulage system Poltrak II – general idea.

The rack ladder segments were interconnected by means of articulated clips that allowed for an adaptation to local changes in the floor deposition. The solution was implemented into common use in the Polish coal mining industry and it was subject to export. In single-drum shearers solutions with a single drive wheel were applied. In the case of double-drum arm shearers, it was necessary to use systems with two drive wheels driven by independent hydraulic motors, but with a single hydraulic feed pump. Through this solution, the conditions of cooperation of drive wheels with rack ladders improved, but the maximum haulage speed decreased by 50%, which was 3.8 m/min. An application of the Poltrak II haulage system allowed (due to the use of hydraulic disc brakes in the haulage system) to eliminate safety drawing equipment (winches) in inclined longwalls. Due to the low haulage speed limiting the shearer efficiency and the availability of the Eicotrack haulage system being easier to operate, the Polish coal mining industry was begun to abandon this solution since the beginning of the 1990s, but in 2002 there were still 13 longwall shearers with the Poltrak II haulage system operating in the Polish mines.

5. Haulage systems with horizontal ladder

At the beginning of the 1970s, the German company Eickhoff [15] started working on a chainless haulage system with a profile bar in the form of a horizontal ladder (two flat vertical bars connected with horizontal pins – a pin rail). Compared to the haulage systems with a vertical ladder, this solution largely eliminated the impact of vertical bending of the conveyor pan route on this type of rack bar. The structurally set clearances allowed for the mutual adjustment of the drive wheel and the ladder while the conveyor was moving and, to some extent, an adjustment to changes in the seam deposition and the positioning (stratification) of the longwall floor. The idea of the Eicotrack haulage system is shown in Fig. 12.

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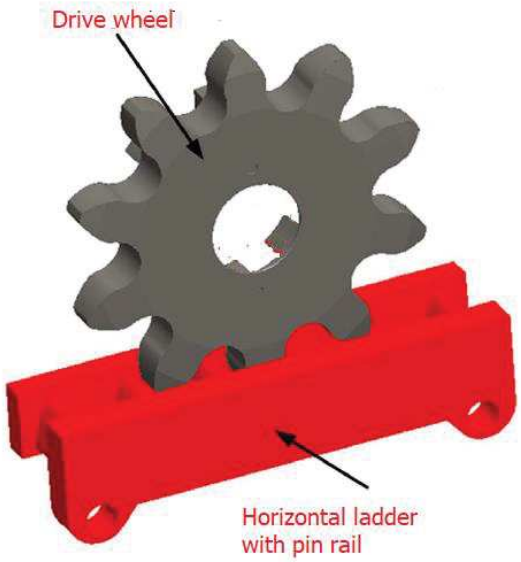

Fig. 12. Eicotrack chainless haulage system– general idea [11].

The Eicotrack was produced with a 125 mm pitch of teeth in the form of segments at the length corresponding to of half-length of the armoured conveyor pan. The production technology has changed, but the segments made with the casting technology dominate today.

With the increase of forces in the haulage systems and the haulage rate of the longwall shearers, functional defects of the system appeared and solutions based on the idea of the Eicotrack system, but adapted to the new conditions appeared, such as Megatrack, Jumbotrack and similar [16,17,18].

5.1. Looking for improvements of haulage systems with horizontal ladder

Despite the fact that the haulage systems of shearers with a horizontal ladder turned out to be much more functional than all the previous solutions, their disadvantages revealed in the long period of operation. As an example, one can point out premature wear and damage to the drive wheels due to a failure to keep the pitch at the connection of the ladders, especially in the case of folded walls or as a result of failure to comply with the technological regime.

Therefore, at the end of the 1970s, some attempts were made to improve this solution. One of the ideas was to replace the ladders with the systems of connected profiled fittings with elements forming the teeth or the pins of the ladder cooperating with the drive wheels of the shearer haulage system. Ideologically, there is some similarity to the haulage systems with captivated chain.

Probably the first solution of such type was patented in the USA in 1982 by one of the British companies (Fig. 13) [19].

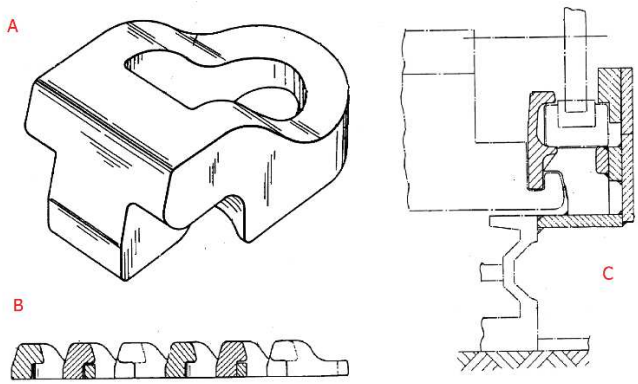

Fig. 13. Modification of the haulage system with a horizontal ladder presented by Pitcraft Summit Ltd.: A – single profile, B – method of profile connection, C – solution idea [18].

The applications of the described solution are not known.

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5.2. Flextrack and Komtrack

An attempt to eliminate the disadvantages of the haulage system solutions, based on the Eicotrack idea, was undertaken in the 21st century in Poland by developing the Flextrack haulage system (2012-2015), later developed into the Komtrack haulage system [20,21,22].

By definition, the new system was intended to:

- improve the durability and reliability of the longwall shearer haulage system,
- reduce time losses caused by the Eicotrack haulage system failures,
- facilitate an adaptation to changes in the longitudinal and/or transverse slopes of the armoured face conveyor,
- reduce the energy consumption of the haulage system.

An additional objective was to limit the exposure of mining operators to mining hazards during repairs of the longwall shearer haulage system.

In view of the widespread use of haulage systems based on the Eicotrack concept, it was rightly assumed to minimize structural changes in other devices of the longwall system. The armoured face conveyor remained unchanged, and the changes in the shearer haulage system actually concerned only minor changes in the geometry of the drive wheel (sprocket wheel) and the associated components.

The idea of the solution shown in Fig. 14 was to replace the classic Eicotrack pin rack with a guide in which, similarly to the solution shown in Fig. 12, specially shaped cast fasteners with a specially adapted geometry were installed.

It should be noted that the widespread use of longwall shearer haulage systems based on the Eicotrack concept, may be an obstacle to spreading of the Komtrack system, even if the field tests prove the benefits of this solution. It is difficult to expect that the Komtrack system will significantly affect the productivity of the longwall systems in the Polish hard coal mining industry, and in the most technologically advanced countries, high-performance longwall systems are used in conditions where the disadvantages of systems based on the Eicotrack concept (Megtrack, Jumbotrack) do not have a significant impact on the reliability of the entire longwall complex.

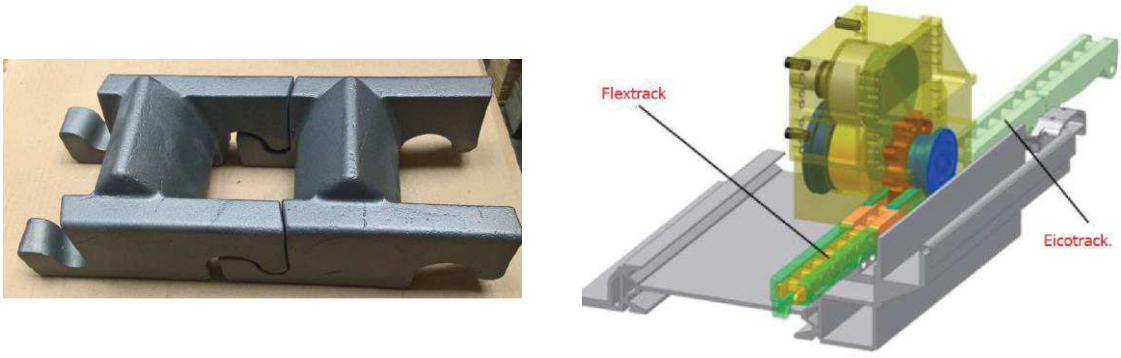

Fig. 14. Eicotrack and Flextrack/Komtrack – idea [21]

Developing the concept of the Flextrak haulage system resulted in the Komtrack haulage system, which, after tests on the surface of one of the Polish mines, has been awaiting to be used in underground conditions.

5. Summary

After several decades of searching for a safe and reliable system of longwall shearer haulage system, the Eicotrack haulage systems and solutions based on the same idea/concept that enable their application in increasingly faster and stronger shearer loaders are now used. The currently abandoned solutions were created in times when the shearers with one cutting drum often embedded in the shearer body (without an arm) were the dominant ones. These first shearers had a limited range of cutting height. With the development of drum shearers, the requirements for haulage systems have changed, and this was one of the first reasons that some solutions were abandoned. The accumulated operational experience concerning the longwall shearer haulage systems, resulted in the search for new solutions or an improvement of the existing ones.

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Today, the dominant longwall shearer haulage system, regardless of the drive type, includes systems with a horizontal ladder (pin rack bar ladder type), ideologically derived from the Eickhoff solution and developed in order to use increasingly greater installed power in the shearer haulage systems and enable a development of increasingly higher speeds in haulage systems.

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