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INFLUENCE OF SHEARER SUMPING ONTO SHEARER COMPLEXES CONDITIONS

Summary. Every mining shearer complex consists of three basic mechanical units: mining shearer, armoured face conveyor and roof supports. While the shearer loads coal onto face conveyor, which transports the coal to collecting pan conveyor, roof supports safe whole working area from falling pieces of stone from rock cover to the area.

Before each mining running, it is necessary to cut-in first time to the wall by ranging drum of shearer. It is called shearer sumping. It is most important working activity of shearer in the longwall and influences or is influenced by some parameters of mining complex (advance, step of roof supports, mutual turn of adjacent face conveyor's plates in horizontal level, etc.). There exist practically two basic technology of working activity – shearer running. They are Uni-directional and Bi-directional cutting system.

WPŁYW PROCESU ZAWRĘBIANIA KOMBAJNU NA PRACĘ ZMECHANIZOWANEGO KOMPLEKSU ŚCIANOWEGO

Streszczenie. Elementami każdego zmechanizowanego kompleksu ścianowego są: kombajn ścianowy (ozn. „kombajn"), zgrzebłowy przenośnik ścianowy (ozn. „przenośnik") oraz komplet obudowy zmechanizowanej. Podczas gdy kombajn urabia czoło ściany i ładuje urobek na przenośnik, transportujący go na zgrzebłowy przenośnik podścianowy, komplet obudowy zmechanizowanej zabezpiecza przedział roboczy wyrobiska przed przypadkowym wpadaniem skał tworzących warstwy stropu bezpośredniego.

Wykonanie każdego skrawu poprzedzone jest „wcięciem" organu urabiającego w czoło ściany. Proces ten nosi nazwę zawrębiania. Zawrębianie jest jedną z najistotniejszych operacji wykonywanych przez kombajn w ścianie wpływającą na parametry kompleksu ścianowego, a równocześnie zależną od niektórych parametrów kompleksu (zabiór kombajnu, krok sekcji obudowy zmechanizowanej, względne ukosowanie sąsiednich rynien przenośnika itd.). Praktycznie stosowane są dwa podstawowe systemy urabiania za pomocą kombajnu – urabianie jednostronne i dwustronne.

1. Uni-directional Cutting System

In this method, the shearer cuts coal in one direction only. The return trip is usually for loading and cleaning the floor coal or travelling empty. It requires one sumping in a round trip (Fig.1). The loading efficiency is very high for this cutting method. If the face sloughs off after cutting, coal loading during the return trip is more advisable. During the return loading trip the shearer can pick up the coal stump left at the bottom as a result of drum jumping during the cutting trip. This way the floor can always remain smooth.

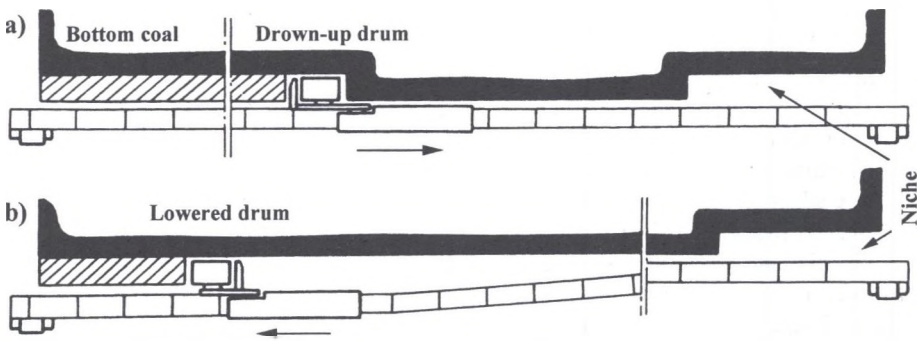

Fig. 1. One drum shearer in face with higher seam thickness then drum diameter
Rys. 1. Kombajn jednoorganowy stosowany w ścianie o wysokości większej od średnicy organu urabiającego

The major disadvantage is that there is only one web cut in a round trip. The percentage of machine utilization time is low. If the powered support is not the immediate forward support (IFS) type, the unsupported area after cutting is larger, and is left exposed longer. Thus, the roof tends to become unstable.

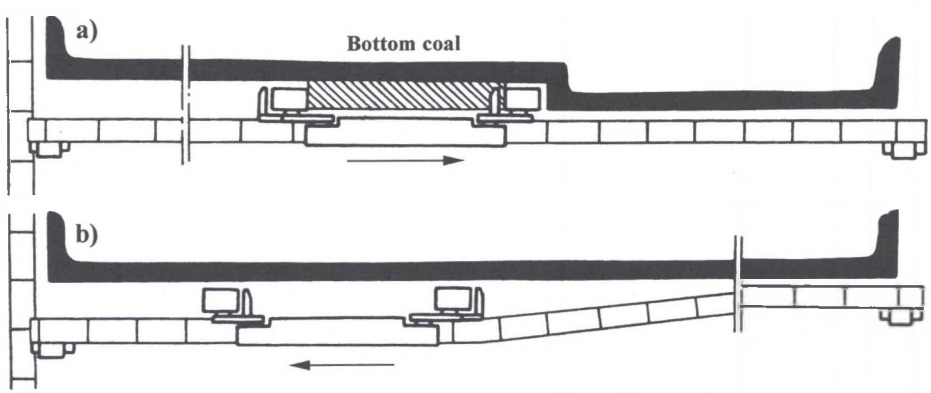

Fig. 2. Two drums shearer in uni-directional mining method
Rys. 2. Kombajn dwuorganowy stosowany w systemie urabiania jednokierunkowego

When the single-ended ranging-drum shearer is used, and if the mining height is larger than the drum diameter and the roof coal sticks to the roof, the forward trip cuts the top portion of the seam and the return trip cleans the bottom coal. If the roof coal does not stick to the roof, the forward trip can be used to cut the bottom portion of the seam and the return trip used for cleaning coal. Since there is only one sumping in a round trip, it is unidirectional cutting. In this case the IFS powered supports should be adopted. During the forward cutting trip, the supports are advanced immediately. The conveyor is advanced during the return cleaning trip. When the double-ended ranging-drum shearer is employed, uni-directional cutting is applicable only to the following conditions (Figure 2): steep coal seams; hard coal seams; deep line pan; excessive coal dust and half-face method. If the cutting is initiated in the middle of the face (i.e., the half-face method), it is unidirectional cutting.

2. Bi-directional Cutting

In the bi-directional cutting, the shearer performs two sumping in a round trip. Thus, in this method a complete mining cycle is accomplished both during the forward and the return trip. A complete mining cycle includes the extraction of the whole seam height, followed by the advance of both the conveyor and the powered supports. Under normal conditions, the leading drum cuts the upper 70% of the seam and the rear drum cuts the remaining bottom and cleans up the floor coal. This is the most commonly used method.

Under special conditions, the leading drum may be used to cut the bottom coal while the rear drum cuts the upper coal seam. For example, a coal seam contains a rock parting, located approximately 1.7 m from the floor. The conventional cutting method was used first. Since the leading drum cut the rock parting, bit wear was heavy. It not only affected the haulage speed, but the shearer could not run smoothly. When the reverse method was adopted, the leading drum undercut the parting, which greatly reduced the cutting resistance when the rear drum came to cut the parting. But the disadvantage for this method is that the coal cut by the rear drum is mostly left on the floor, which means the coal loading efficiency is low.

3. Multiple-Shearer Operation

The two-shearer-operation of a longwall face utilizes the space and the time well and thus increases the rate of face advance. When one shearer breaks down, the other one can still continue to operate. If one shearer breaks down at the middle of the face, it can be pushed to the face end by the other shearer for repair without interrupting production.

The production organization in a two-shearer-operated longwall face is more complex. Its engineering qualities are more difficult to control. Therefore it requires high-level production operation and management. Because the conveyor is advanced from the centre toward both ends of the face, there will frequently be more snaked section than would be in a one-shearer face. Therefore maintaining an excellent operation in conveyor advance requires extra care. If the roof permits, the face conveyor can be advanced simultaneously along the whole face.

The disadvantages of the two-shearer operation are that it requires more equipment installation and maintenance for power transmission; when the mining height is low, the cross-sectional area beneath the under frame is relatively small, and therefore coal and rock cut by the tail-end shearer will affect the normal travel of the head-end shearer; because the tail-end shearer is always near the return side of the air flow, if the coal is dusty and rich in methane, a two-shearer operation is not suitable; and for steep seams, it is difficult to operate both shearers simultaneously because they are both equipped with a safety hoist.

4. Methods of Sumping

Each time the shearer completes a cut along the whole face, the faceline moves forward a distance equivalent to a cutting web. Before starting the next cut, the drum must first cut into the coal face. The process of making the drum cut into the coal face is called sumping. Each method of sumping requires a certain length of time and travel distance. The method of sumping is directly tied to the amount of niching required at both ends. Thus, sumping is a major factor affecting the operational efficiency of the shearer. There are three types of sumping: push sumping (preniching), drill sumping (selfniching), and inclined sumping (no niching). The inclined sumping is most widely used.

Push Sumping - In some longwall faces, the tail and head drive are taller and the ranging arm of the shearer is shorter. The shearer cannot cut and load coal within a short distance

from the face ends. Thus some other methods must be used to cut and load the coal in these areas in advance. The conventional practice is to precut these portions and call it the niche. When the shearer approaches either end of the face, it is pushed into the niche by the advance of either the tail on the head drive. The shearer can then proceed as usual to cut and load coal in the return trip. The method are not used on OKR mines just now.

Drill Sumping - In drill sumping, the drum is directly sumped endwise into the coal face by using the bits mounted on the face end of the drum and the hydraulic pushing force of the rams. It is also called self-niching. Obviously for this type of sumping, it must have bits laced on the face-end side of the drum and a dozer plate.

Inclined Sumping - In inclined sumping, the shearer cuts gradually into the coal face, following the snaked section of the conveyor. If the tail and head drive are short and the ranging arm has a sufficient length, inclined sumping can be used without resorting to niching. When the double-ended ranging-drum shearer is used, no niching is required at either end. However, if the single-ended (either single- or double-drum) ranging-drum shearer is used, a niche is necessary at the tail end but not at the head end.

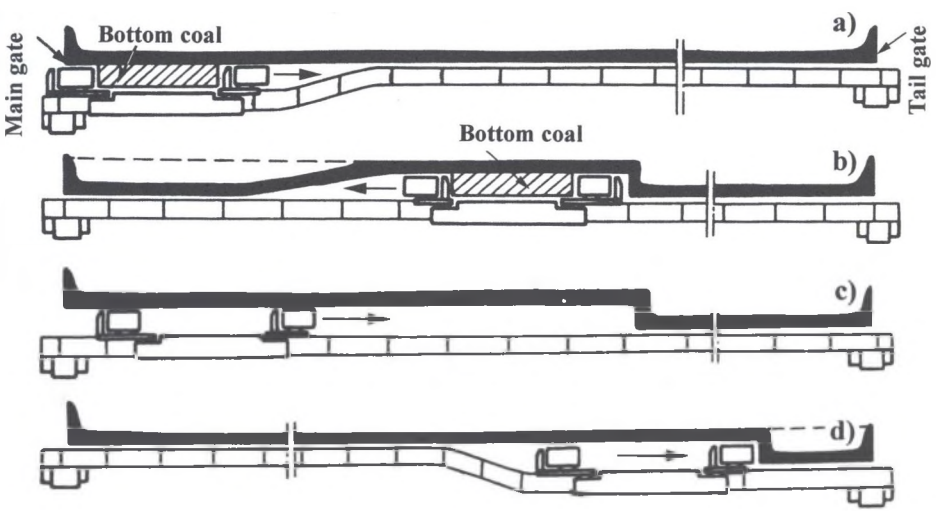

Fig. 3. Shearer sumping in bi-directional mining method
Rys. 3. Zawrębianie kombajnu w przypadku urabiania dwukierunkowego

Very common used method on our mines is Full-face Triangular Inclined Sumping. During the cutting trip, as the shearer arrives at the head end, the haulage motor is stopped (Figure 3). The leading drum is lowered to the floor level while the rear drum is raised. The shearer moves toward the tail end by following the snaked section of the conveyor. The

shearer gradually cuts into the coal face (the rear drum also cleans up the stump left between the two drums during the previous trip).

A distance of 25 to 30 m is needed before both the leading and rear drums reach the full one-web cutting width. At this time, the shearer is stopped, the leading drum is lowered and the rear drum is raised (Figure 3b). The cowl is turned 180°. The shearer is reversed and proceeds toward the head end to cut the triangular coal block. After reaching the head end, the operation shown in Figure 3a is repeated to turn the shearer around (Figure 3c). The shearer flow proceeds toward the tail end, cutting the coal in the normal fashion (Figure 3d). Inclined sumping is suitable for bi-directional cutting.

In this method, no niching is required. The tail and head drive can be advanced independently without stopping the conveyor. The disadvantage is that the repeated trips for cutting the triangular coal consist of two shearer stoppages and reversing. The shearer travels empty for a short distance near both ends. It is not suitable for the single-ended ranging-drum shearer if the mining height is large and unidirectional cutting is employed.

When the shearer begins to cut coal from the tail toward the head end, the sumping procedure is similar to the full-face triangular inclined sumping (Figure 4a). Instead of reversing to cut the triangular coal block, the shearer moves directly toward the head end (Figure 4b). The triangular coal block is taken off during the returning trip (Figure 4c). Similar sumping procedures are employed at the head end.

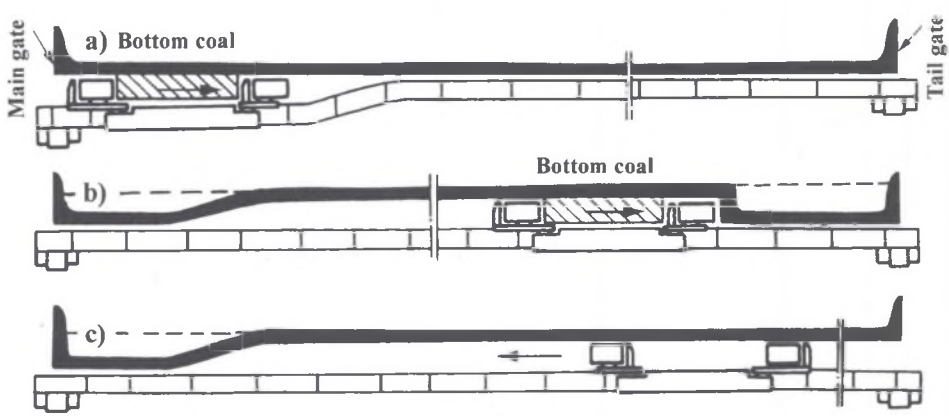

Fig. 4. Double ranging drum shearer in unidirectional mining system
Rys. 4. Kombajn dwuorganowy w systemie urabiania jednokierunkowego

In comparison with the full-face triangular inclined sumping, this method eliminates the time required to cut the triangular coal block and the associated machine stoppages. It also

reduces the number of machine reversing required. But it can only be used for unidirectional cutting.

In the case, shearer is used in uni-directional mining system it is better to use half face inclined sumping method. This method is speciality designed for the double-ranging drum shearer which sumps into the coal at the middle of the coal face. No niching at either face end is needed if each side of the shearer has a ranging drum.

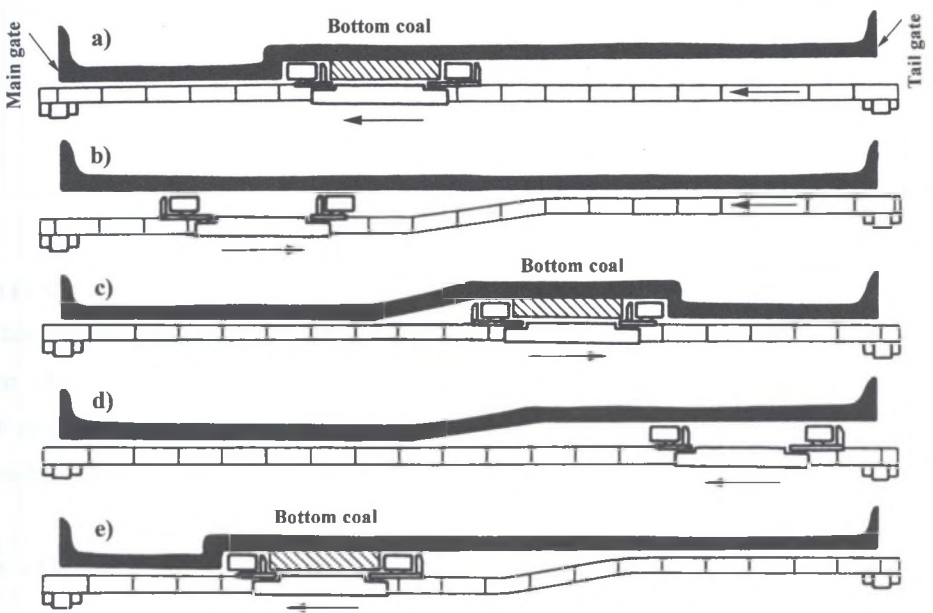

Fig. 5. Double ranging drum shearer in half face inclined sumping method
Rys. 5. Zawrębianie kombajnu dwuorganowego w połowie długości ściany

The shearer moves and cuts coal from tail to head end. When it reaches the middle of the face, the conveyor and the supports are advanced from the middle toward the tail end. Meanwhile, the shearer continues to move until it reaches the head end (Figure 5a) where the cutting and loading procedures are stopped. After finishing the face-end operations, the shearer is reversed and then travels empty until it reaches the middle of the face (Figure 5b). It follows the snake of the conveyor and gradually cuts into the coal face. Meanwhile the conveyor and the supports are advanced from the middle toward the head end. At this time, the conveyor and the supports form a separate straight line across the whole face (Figure 5c). When the shearer reaches the tail end, the procedures are repeated to complete the face-end operations. The shearer then reverses and travels empty (Figure 5d) until it reaches the middle of the coal face, where it begins to cut the triangular coal block until it reaches the head end

(Fig. 5e). Meanwhile, the conveyor and the supports are advanced from the middle toward the tail end. After the face-end operations, the shearer travels empty until it reaches the middle of the coal face where the whole procedure repeats.

Using this method, there is no need to sump the coal back and forth, thus reducing the face-end operations. It is more flexible because the sumping location can be determined based on local conditions. The workload is more uniform between the two half-faces. The floor is much cleaner. But the shearer travels empty for half a face in each trip. It is‘ strictly speaking‘ a unidirectional cutting. To prevent the conveyor from lifting upward‘ the conveyor and supports should be advanced from the middle toward both ends.

5. Conclusion

Mines used longwall face shearer complexes, when was early mentioned, apply two kinds of shearer coal exploitation, mining technology respectively. They are Uni-directional and Bi-directional cutting system. Using of Bi-directional moving system is appreciate more productive at more long faces, but with higher output complexes and at longwalls with high seam thickness Uni-directional system could be more able to compete and more productive then Bi-directional system

If personal computer control system of roof support is on sufficient level, could be used half-web sumping system (Figure 6). Basic of the system is Uni-directional exploitation. The wall is cut at half web system in middle of the longwall face (except main and tail gate areas) by shearer. Coal output of the longwall face is keeping by higher shearer speed travel. It is evident, that simultaneously reduced load of shearer driving units and other mechanical units.

The half-web system is basically a Uni-directional system of extraction in mid face, with Bi-directional gate sequences. Faster shearer and cutting cycles may be possible because the ‘shuffle’ required for the Bi-directional cutting is not required, and loading on the shearer drums is reduced, allowing increased cutting speeds.

The half-web is achieved by pushing the AFC 50% after the supports have advanced to provide a half web cut for the return shearer run. This provides a pre-splitting effect on the coal, reducing lumps and if managed correctly, can equalise the coal flow in each cutting direction, an important issue if out bye capacity limits face production.

The half web system requires a modern support control system, such as the Joy RS20 or DBT PM4 system to operate effectively. Support hydraulics should also be highly efficient

and well maintained. If you have such a system, then significant cutting cycle benefits may be possible, over and above your current cutting rate.

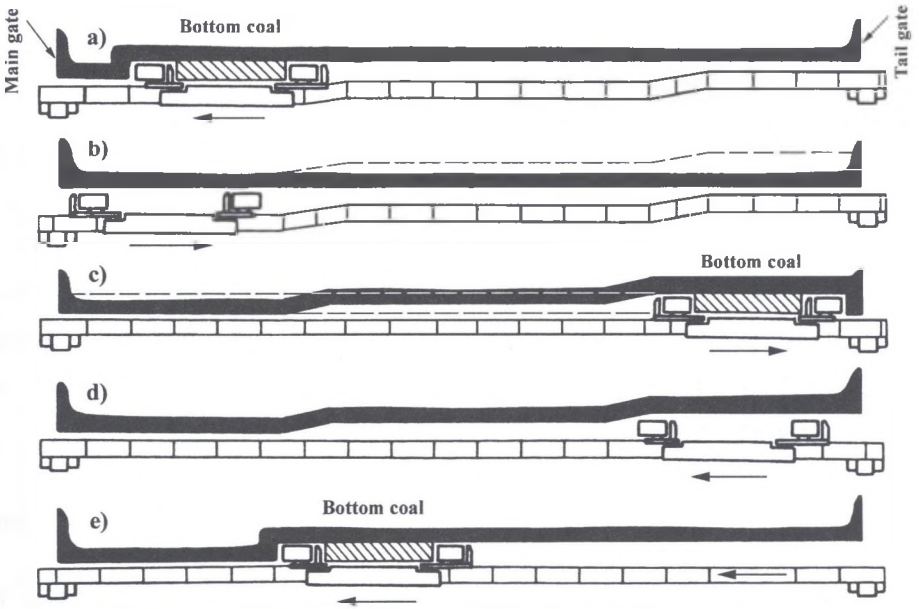

Fig. 6. Double ranging drum shearer in half-web sumping system
Rys. 6. Zawrębianie kombajnu dwuorganowego w systenie „do połowy zabioru"

There is also evidence that improvements may be available in the areas of equipment loading and wear rates, environmental management and face management and control. Potential Advantages:

- Distances travelled with shearer same as Uni-directional cutting,
- Environmental conditions are superior to Bi-Di and Uni-Di and equate to the 'forward' snake conditions in Uni-Di,
- Shearer speeds can be increased due to less coal being cut in main cut (providing conditions allow), increasing potential cutting rates,
- Cutting profile is used to reduce lumps by pre-cutting the seam on each run up and down the face. (The more the seam holds up the better the control),
- 50% push from tailgate allows greater distance between face and AFC for lump movement,
- Drum positions can by varied to allow tonnage cut to be more evenly distributed on each pass of the face, a great benefit in thick seams,
- Half web can be varied within the support control system program to allow advance to be varied to suit mine conditions and potential problems,

- Snaking distances are shorter, reducing wear and damage potential,
- Snaking distances are halved and so cutting into gates is quicker,
- Creep may be better controlled as snaking is done in both directions,
- Majority of horizon control cutting is done with the maingate drum (as per Uni-Di) so no tailgate operator is required,
- Allows Auto-steering to be used the same as Uni-Di cutting and so shearer operations remain similar to existing conditions.

Disadvantage is, when it mentioned, roof supports control equipment requirement. The control system must be on higher level then common used. It is no familiarly demand choosing full or/and half roof support step (roof support are moved by constant distance). Manual control could be used equipped providing that high experiences staff. In table no. 1 are describe summary of system benefits and difficulties.

Table 1

Summary of system benefits and difficulties

Cutting System	**Bi-Directional Cutting**	**Uni-Directional Cutting**	**Half Web Kaiser Cut**	**Half Web High Seam Variant**
Relative Complexity of System	Most Complex	Simple	More Complex as Bi-Di cut needed	Complex More akin to Uni-Di
Cycle time on 200m face 10 $m.min^{-1}$	36 s	46 s	46 s	48 s
Faster Shearer speed needed for same level of production	-	> 13 $m.min^{-1}$	> 13 $m.min^{-1}$	15 $m.min^{-1}$
AFC Loading: • To Maingate • To Tailgate	 Standard Standard	 Reduced Substantially Low	 Reduced Substantially Low	 Lower&Balanced Lower&Balanced
Snake Length	Standard	Standard	Half Standard but two half snakes	Half Standard but two half snakes
Double Snake on Face	No	No(for backward) Yes (for forward)	Yes (only 50%)	Yes (only 50%)
Balanced AFC Loading	Yes	No	No (unless drum matched to seam)	Yes (High Seam especially)
Reduced Loading on Shearer	No	Yes (depending on seam section on main cut)	Yes	Yes
Precutting Face	No	No	Yes Middle of Face	Yes Top & Middle of face
Bench to support face	No	Yes	Minimal	Yes
Reduced Slumping in front of Shearer	No	No	No	Yes
Reduced Lumps travelling to Maingate	No	No	Yes	Yes
Improved Loading of Loose Coal	No	No	No	Yes
Increased clearance on face side for coal	No	No	Yes	Yes

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