Disintegration of a roof coal while developing powerful seams with a controlled coal release

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Abstract. The technology of thick seam development with roof coal release on the face conveyor which allows increasing the coal flow, reducing the losses and stand-by-time of the stope is worked out by the Institute of Coal of FRC CCC SB RAS. Disintegration of roof coal preparing it for release can be done during gradual advancing of a stope or in advance, applying the method of interval hydraulic fracturing before starting stoping.

1. Introduction
The most perspective direction of underground mining of thick flat seams is a power-driven development in one layer of roof coal with release on a goaf or a face conveyors (Longwall top coal caving method – LTCC). These technologies apply rock pressure for disintegration of roof coal [1-4]. At present, in the world practice, the equipment with additional goaf conveyor is used (Russia, China, Australia, Turkey, Bangladesh) [5-9]. Powered roof supports are delivered by “Caterpillar” Firm and “CODCO” (China) [10]. Additional goaf conveyor complicates the complex structure and requires significant increase of a roof support unit size and adding an extra stage loader at the head-gate and all this complicates the maintenance.

2. The technology of roof coal release onto the face conveyor
The works on creating the technology of roof coal release onto the face conveyor has been carried out at the FRC CCC SB RAS. At the basis of the technology the application of powered roof support of shielding and supporting type (KUV 1 – a support with a controlling release) is taken. This powered roof support has a discharge port in shielding walls which is linked to a loading chute and a feeder (figure. 1) [11]. A discharge port in a roof support unit is two-times larger than the existing analogous ports and due to its oversizing it allows increasing the coal flow and reduce the losses and stand-up time of the stope. Light weight of the sections (17 tones) allows developing weak soil seams.

However, if during releasing onto the goaf conveyor the roof coal disintegration is done by a rock pressure than for releasing on the face conveyor rock pressure is not enough; the technology requires roof coal disintegration. The thickness of the released top coal can vary in a large scale depending either on the thickness of the layer or on the applied mining technology [12].
2.1. Portioning the massif by a mechanic cleaver blade
Disintegrating the roof coal can be done in advance i.e. earlier than starting the extraction of the coal panel or simultaneously with stoping. Preliminary disintegration of the roof coal provides weakening of the unmined coal, its simultaneous preliminary partial degassing and, as a rule, increasing the effectiveness of coal mining and safety stoping. Disintegration during advancing the stope face allows nearly equal portioning of the roof coal area. It makes the coal release and its further loading on the face conveyor more convenient and allows controlling the time of staring the release.

Depending on the thickness of the released roof coal its disintegration during advancing the stope can be done applying different technical tools and equipment, for example, for roof coal with thickness up to 1 meter a mechanical cleaver blade oriented across fractures prevailing direction (figure 2) can be installed on the at the canopy of the powered support unit [13].

After each shift of the powered support unit the cleaver blade enters into the roof coal cleaving and portioning it. The caving of the releasing coal portion takes place directly above the discharge port of the powered support unit.

2.2. Portioning the massif by dynamic cleaver blade
To disintegrate thick roof coal of 1 -2 meters a dynamic cleaver blade installed into the inner side of the barrier can be used (figure 3) [13]. After shifting the powered support unit the cleaver blade moves out of the barrier dynamically influencing on the roof coal bringing about caving of the released coal portion.
Figure 3. The scheme for disintegrating the massif by dynamic cleaver blade: 1 – powered-support unit canopy (bridge); 2 – a barrier; 3 – discharge port; 4 – dynamic cleaver blade; 5 – a face conveyor.

2.3. Partitioning the massif by the dynamic cleaver blade along the weakening bores
Artificial caving of the thick coal roof requires additional impact. In this case a powered support equipped by the dynamic cleaver blade and special channels in a canopy (bridge) for drilling weakening the massif bores can be used (figure 4). Out of the operational space of the slope through the channels in a canopy (bridge) a number of bores are drilled along the whole thickness of the roof coal, the more the bores are drilled the better the weakening effect is. After shifting the powered-support unit along the line of the bores the dynamic cleaver blade is used dividing the portion of the released coal.

Figure 4. The scheme for disintegrating the massif by dynamic cleaver blade along the lines of the weakening bores: 1 – powered-support unit bridge (canopy); 2 – a barrier; 3 – discharge port; 4 – dynamic cleaver blade; 5 – a face conveyor; 6 – a channel in a powered-support canopy (bridge).

2.4. Disintegrating roof coal by cutting lengthwise channels in a crown pillar of a sill cut
The above mentioned options of disintegrating roof coal carried out during shifting the stope in a sill cut require equipping the powered-support unit with additional tools. The authors worked out the technological option for disintegrating roof coal and portioning of the released coal which appear while advancing the stope using the resources of the cutter-loader.

The idea of this technical solution is that in the sill cut (underlying rock), when mining every second line by a cutter-loader, the upper drum is lifted higher than the canopy (bridge) of the powered-support unit, the higher the better (figure 5) [14]. Moreover, along the line of the slope in a crown pillar of a sill cut several lengthwise channels with the width equals to a volume of the combined machine grip are formed and rib pillars of the same width are left. Due to this the powered-support units after shifting are strutted off not into a solid roof of a sill cut but into a rib pillars between the lengthwise channels. Depending on the physical properties of the coal the pillars, bearing the load from the side of the powered-support canopy/bridge are partially destructed and pass the compressing
force to an upper layer. The channels do not bear the thrust force from the powered-support unit but bear the pressure of the upper layer, i.e. from the reverse direction, which expands the surface of the channels.

Two or three shifts of the powered-support unit provide the cracking of the roof coal and this prepares it for releasing the coal. Thus the most prepared part or the portion of the massif appears directly above the discharge port of the powered-support unit.

![Figure 5](image)

**Figure 5.** The scheme for disintegrating the roof coal by cutting the lengthwise channels in a crown pillar of a sill cut: 1 – cutter-loader; 2 – a face conveyor; 3 – powered support unit canopy/bridge; 4 – lengthwise channel; 5 – rib pillar.

According to the results of the mathematic modelling of the roof coal stress-strained behavior carried out by the Siberian State Industrial University (Novokuznetsk, scientific advisor of the work Doctor of engineering science V.N. Fryanov) it is found out that the following factors influence on the values of the ratio between the remaining and initial strength: the quantity and the size of the channels, the rate of the strutting off the powered support unit and presence of special cleaver blades at the upper canopy (bridge) of the section. When strutting off the unit over 2000 kN the shifting of the roof coal to the side of the mined-out space takes place, i.e. vertical and cross-section fractures are formed and the coal massif is distracted under the influence of the tension horizontal stresses. It is found that such decrease of the ratio between the remaining and initial strength is more intense (in 1.15 times) when there are channels in the roof coal. It is connected with the fact that the pillars between the channels are disintegrated and the stress relaxation takes place, i.e. that fundamental principles introduced in Russian patent of invention are proved [14].

### 2.5. Preliminary preparation of the roof coal to the release induced by hydraulic fracturing method

While developing the seam with a greater thickness of 5 and more meters it is important to prepare the roof coal to the release on the face conveyor. For that a preliminary disintegration of the upper part of the roof coal directly adjoined to the roof rocks is needed to be carried out. In this case the link of the seam with the roof rocks and coal continuity is broken.

The most effective option for disintegration of the roof coal is a method of hydraulic fracturing which is carried out before starting the stoping [15]. In a roof coal somewhere along the center line of the extraction panel a sub-drift is done and out of it into both sides the bores are drilled. They are oriented in the bed plane paralleled to a supposed sloping line (figure 5). Then, using downhole devices the hydraulic fracturing of the upper layer with simultaneous intensification of the degassing process is carried out. When carrying out the stoping, if it is necessary, disintegration of the releasing coal layer by one of the above-reviewed methods are done.
Figure 5. The scheme for preparing disintegration of the upper part of the roof coal to the release by hydraulic fracturing method: 1 – a conveyor drive; 2 – a windway; 3 – a sub-drift; 4 – a top-hole; 5 – a down – dip hole.

The technology for developing thick (powerful) flat seams with roof coal release on the face conveyor is possible using powered-support unit KUV1 (powered support with a controlled release) крепь с управляемым выпуском, in the shielding of which a discharge port two-times larger than the existing analogues is done. The size of the discharge port allows increasing the coal flow and reduce the losses and stand-up time of the stope. However, it is important to prepare the roof coal for the future release.

Disintegration of the roof coal preparing it to the release can be done during the shifting of the stope not triggering the rock spalling in front of the sections of the support by cleaver blades (mechanical, dynamical, cutting lengthwise channels in a crown pillar of the sill cut).

While developing the seams with a roof coal thickness of 5 and more meters the upper part of the seam adjoining to the roof rock is prepared for release by hydraulic fracturing method, before starting the stoping. As for the lower part of the roof coal it is prepared for release during advancing of a stope.

3. Conclusions
In a technology of releasing a roof coal on the face conveyor a powered support of shielding and supportive type KUV1 (powered support with a controlled release) with a discharge port in a shielding wall linked with a loading chute and a feeder is used. The discharge port of the support unit which is two-times larger than the existing analogues allows increasing the coal flow and reducing the losses and stand-by time of the stope due to its size. Light weight of the sections (17 tones) allows developing weak soil seams.

However, this technology requires disintegrating the roof coal during advancing the face or beforehand. Thus the thickness of the released roof coal can vary widely depending not only on the thickness of the seam itself but on the applied developing technologies: portioning of the massif by cleaver blades (mechanical, dynamical and using the weakening bores); cutting lengthwise channels, hydraulic fracturing of a seam before starting stoping.

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