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Operating Load of Belt Conveyor as a Reflection of Actual Planogram of Coal Shearer Operation in Integrated-Powered Face

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Abstract: Conveyor transport at a modern coal mine is the main link that determines the overall performance of the enterprise. For safe operation of belt conveyors, it is important to ensure that shift output per face doesn't produce average and maximum minute material flows, which exceed strength margin of the belt, power margin of the drive, and receiving capacity. Such situation, as a rule, may arise due to the strive of workers to compensate for underproduction caused by long downtimes of a face for any reason. In the paper, a method is proposed that enables determining the maximum shift output per face. According to the technique described in the "Basic Provisions for Designing Underground Transport of New and Existing Coal Mines," the average minute material flow, which determines the operational load on a belt conveyor, depends on the material feed time factor. Accepting the assumption that a coal shearer works the entire shift in a face, the limiting value of the material feed time factor is equal to 1. To determine the actual value of this factor, it is proposed to determine the face operating (production) time using actual planogram. The shift time is spent for preparatory and finishing operations, the face equipment and conveyor line troubleshooting and failure recovery, auxiliary service operations and, finally, operational and organizational downtimes. On the actual planogram, these time intervals are displayed by straight-line portions. Thus, the shift time minus downtime for any reason, represents the face production time. The ratio of these values represents the operation factor. Applying the operation factor allows to determine the maximum limiting face production, not only taking into account the volume of coal mined per cycle, but also based on coal cuttability and technical specifications of the face equipment. This enables us to determine the face production load that ensures safe operation of the belt conveyor.

Keywords: belt conveyor, output per face, average and maximum minute material flows, material feed factor, conveyor operating load, operation factor, down-time.

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Эксплуатационная нагрузка ленточного конвейера как отражение действительной планограммы работы комбайна в комплексно-механизированной лаве

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Аннотация: Конвейерный транспорт на современной угольной шахте является главным звеном, определяющим эффективность работы предприятия в целом. Для безопасной эксплуатации ленточных конвейеров важно, чтобы от сменной нагрузки на лаву не возникали средний и максимальный минутные грузопотоки, при которых не обеспечиваются запас прочности ленты, запас мощности привода и приемная способность. Такая ситуация, как правило, возникает при стремлении работающих компенсировать потерю добычи после длительных простоев лавы по любой причине. В рамках статьи предложен инструментарий, позволяющий определять максимальную сменную нагрузку на лаву. Согласно методике, изложенной в «Основных положениях по проектированию подземного транспорта новых и действующих угольных шахт», средний минутный грузопоток, определяющий эксплуатационную нагрузку на ленточный конвейер, зависит от коэффициента времени поступления груза. Если принять допущение, что комбайн в лаве работает всю смену, предельная величина коэффициента времени поступления груза равна единице. Для определения действительной величины этого коэффициента предлагается определять время работы лавы по добыче по действительной планограмме. Время смены тратится на выполнение подготовительно-заключительных операций, на устранение неисправностей и отказов оборудования лавы и конвейерной линии, на выполнение вспомогательных операций по обслуживанию и, наконец, на эксплуатационные и организационные простои. На действительной планограмме эти промежутки времени отражены прямолинейными участками. Таким образом, время смены за вычетом времени простоев по любым причинам, представляет время работы лавы по добыче. Отношение этих величин представляет собой коэффициент эксплуатации. Использование коэффициента эксплуатации позволяет определять предельную нагрузку на лаву не только с учетом объема угля, добываемого за цикл, но и с учетом сопротивляемости угля резанию, с учетом технических параметров забойного оборудования. Это дает возможность определять эксплуатационную нагрузку, обеспечивающую безопасную работу ленточного конвейера.

Ключевые слова: ленточный конвейер, нагрузка на лаву, средний и максимальный минутный грузопотоки, коэффициент поступления груза, эксплуатационная нагрузка на конвейер, коэффициент эксплуатации, время простоев.

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Conveyor transport, being the core transport facility, determines mine effectiveness. Rational and safe operation of conveyor transport is ensured only with a shift load meeting that given in the "Face operation certificate of excavation section." However, in a real-life situation, a need arises to increase a face load per shift to compensate for losses of production due to long downtime for any reason [1, 3–11]. Therefore, the maximum allowable face load per shift should be determined, the excess of which leads to emergency conditions when operating conveyor transport.

This paper proposes an instrumentarium allowing determining the maximum face load per shift, which ensures safe operation of conveyor transport. For this, two conditions must be observed:

– the maximum minute flow of a coal shearer should not exceed the receiving capacity of a belt conveyor,

– the belt conveyor operational load due to the face load per shift, should provide strength margin of the belt and power margin of the drive.

The belt conveyor operational load depends not only on the face load per shift, but also on the time during which the load arrives on the conveyor. According to the methodology [2], the operational load is determined by the formula, t/h,

$$Q_э = 60 a_{1_{(n)1}} k_t ,$$

where $a_{1_{(n)1}} = \dfrac{A_{см}}{60 T_{см} k_п}$ – is the average minute load flow, t/min; k_t – the estimated load factor, taking into account the uneven load flow during the load passage along the entire length of the conveyor; $k_п$ – the load (material) feed time factor (governed by time of feeding the material on a belt conveyor).

The load is fed on a belt conveyor mainly during coal cutting and face cleanup during a shearer operation by one-sided scheme; therefore, factor $k_п$ is determined by the formula

$$k_п = \frac{t_п + t_з}{60 T_{см}} N_ц \leq 1.$$

In the case when an attempt is made to increase the face load per shift in order to compensate for production losses due to unforeseen downtime, the load feed (on a belt conveyor) time factor can be taken equal to unity. It should be borne in mind that the shift time cannot be fully used for a face production time. The shift time is spent for preparatory and finishing operations, the face equipment and conveyor line troubleshooting and failure recovery, auxiliary service operations and, finally, operational and organizational downtimes. On an actual planogram, these time intervals are recorded in rectilinear horizontal sections (Fig. 1).

Thus, the shift time minus downtime for any reason represents a face production time

$$T_{рл} = T_{см} - T_{пз} - T_{ун} - T_{во} - \ldots - T_{эо}, \text{ min.}$$

The ratio of a face production time per shift to the shift time is called the factor of an integrated-powered face and the conveyor line equipment operation $k_{экс}$: $k_{экс} = T_{рл}/T_{см}$ or $k_{экс} = T_{рл} N_{см}/T_{сут}$.

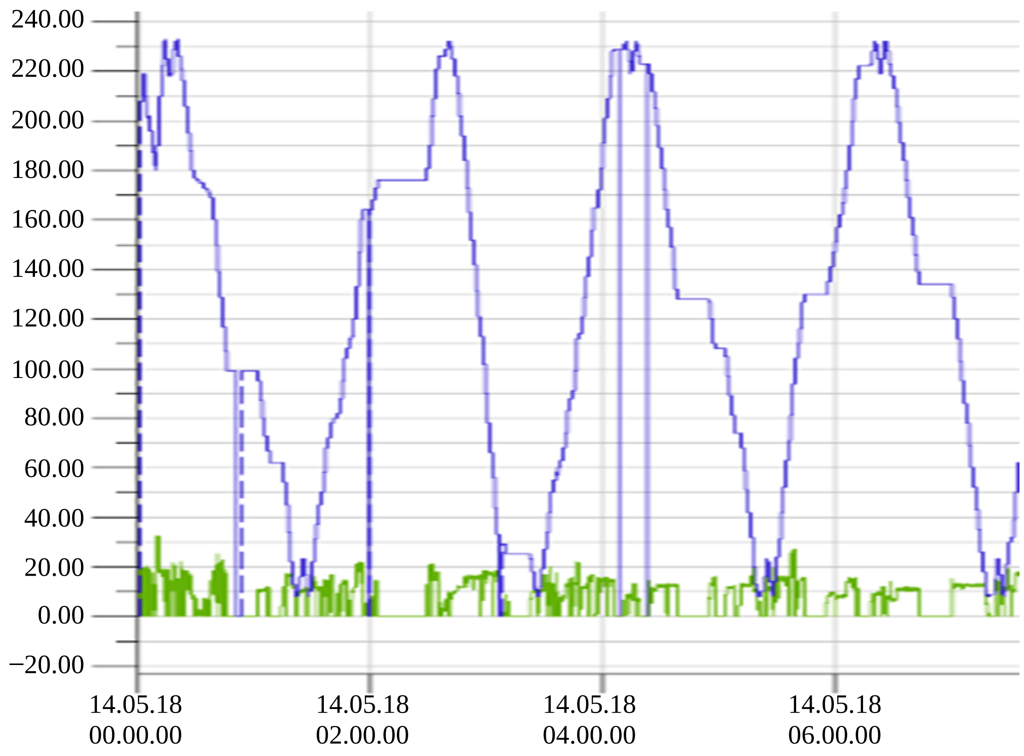

Fig. 1. Actual planogram of face operation

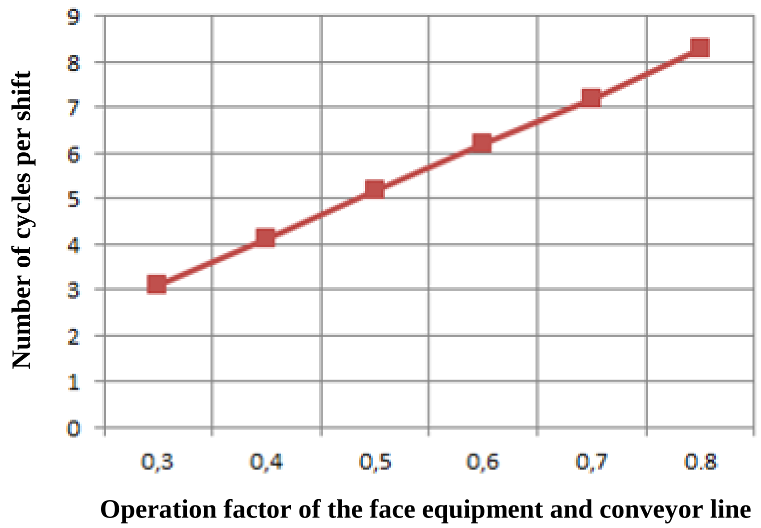

Fig. 2. The dependence of the number of cycles per shift on the operation factor $k_{экс}$ at the cycle time of 65.2 minutes by the example of 52-13 face

The operation factor obtained by this way reflects not only mining and geological conditions (seam thickness, coal density in the solid, coal cuttability, face length), but also the equipment technical specifications (working width, power of electric motors of the shearer's working members, the possible feed rate when cutting and at cleanup. In addition, the equipment condition (downtime due to failures, time spent on troubleshooting, as well as the staff skills and competence (the time spent for face preparatory and finishing operations and operational and organizational downtimes).

Based on these assumptions, we obtain the expression

$$1 = \frac{t_п + t_з}{60 T_{см} k_{экс}} N_ц,$$

which allows determining the number of cycles per shift based on the time of a cycle performed by a shearer:

$$N_{цт} = \frac{60 T_{см} k_{экс}}{t_п + t_з}.$$

The obtained dependence, taking into account the real-life factor of the integrated-powered face and conveyor line specific equipment operation, allows to accurately plan a shift load.

At the same time, technologists, planning the face load per shift, determine the number of cycles per shift based on the amount of coal per cycle

$$N_{цу} = \frac{A_{см}}{m b L_{оз} \gamma_ц}.$$

Ultimately, in order for the calculations to reflect reality, it is necessary to comply with the condition

$$N_ц = N_{цт} = N_{цу}.$$

The achievement of this equality is facilitated by using the operation factor obtained based on treatment of the actual planogram (see Fig. 1).

Based on this equality, the actual load per shift should be determined by the formula, t,

$$A_{см} = \frac{60 T_{см} k_{экс} m b L_{оз} \gamma_ц}{t_п + t_з}.$$

Conclusions

Applying the operation factor obtained based on treatment of the actual operation planograms for integrated-powered face and conveyor line equipment allows to accurately determine and plan a maximum face load per shift, taking into account:

– volume of coal mined per cycle,

– coal cuttability,

– technical specifications of the face equipment,

– staff competence,

– achieved workflow management sophistication level.

This enables determining the face production load that ensures safe operation of the belt conveyor.

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