POSSIBLE CAUSES OF DYNAMIC PHENOMENA IN COAL MINES

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Experience of routine prediction and observation of gas bursts and other dynamic phenomena reveals that they sometimes occur when there are no observed changes in the strength properties or lithology of the seam. Changes in the physical properties of a seam can favor the development of dynamic phenomena, but are apparently not the leading factor in the creation of a burst-prone situation.

Therefore it seems necessary to pay particular attention to processes occurring in the rock during the driving of mine workings, to the laws of roof and floor convergence, to the laws of variation of the process of brittle fracture of a coal seam under changing rock pressure, and to the temporal and spatial features of these processes during the period preceding the dynamic phenomena. The success of seismoacoustic prediction of bursts and shock bumps [1, 2] assures us that this is a very promising route for developing a theory of gas bursts, shock bumps, and rock falls, and for further improvements in our methods of routine prediction of the danger of these phenomena.

Dynamic phenomena occur in zones of a seam which are being worked with anomalous increase in disintegration of the coal [3-5]; according to the current method of prediction [5], this zone is regarded as burst-prone throughout its length.

A rise in pressure on the face zone can be due to an increase in the length of the main roof rock cantilever overhanging the working. The descent of the main roof rock can be very nonuniform. It sufficiently stiff layers are encountered in the roof rock, roof descent is held up, the size of the hanging roof cantilever increases, and the pressure on the face zone of the seam increases; simultaneously there is also an increase in the brittle fracture of the face zone, and this is quickly detected by seismoacoustic equipment which detects a rise in the noise level. If the pressure of the hanging cantilever of main roof rock is so great that the face zone of the seam and the supports of the immediate roof cannot sustain it, the immediate roof rock may fall into the worked-out area.

When the hanging cantilever of main roof rock breaks off, the face zone of the coal seam is suddenly relieved of load, and, as investigations have shown [7], there may be a gas burst: the probability of this increases with the difference between the pressures on the face zone before and after breakaway of the rock cantilever, i.e., with the length of the hanging cantilever of roof rock.

Consequently, the period of extraction operations before breakaway of the rock cantilever and during actual descent of the main roof is liable to dynamic phenomena.

To make successful routine predictions of the risk of dynamic phenomena, it is necessary to examine the zone of the seam worked with long hanging rock cantilevers. An effective approach to studying and to determining the interval of descent of the main roof is correlation analysis of seismoacoustic observations, which enables us to study the periodic components of the process of coal disintegration in extraction workings.

Correlation analyses of the process of disintegration were made on the data from seismoacoustic recordings in a number of seams in the "Yunkom" pit in the Central region of the Donbass in 1965-1970.

The Central Scientific-Research Seismoacoustic Station of the Donbass investigated the current correlation functions of the relative daily noise in the burst-prone seams "Zolotarka" (District 23, Hor. 716 m, 1967-1968), "Devyatka" (District 78, hor. 716 m, 1967-1968), "Tolstiy" (District 41, hor. 716 m, 1969), "Mazur" (District 90, hor. 716 m, 1969-1970), and "Bezymyannyi" (District 147, hor. 596 m, 1963 and 1965). The relative daily noise
level is defined as the number of disintegration pulses detected by the seismoacoustic equipment during one day, divided by the number of hours of extraction operations. The correlation functions were calculated over an interval of 30-40 days (which, at normal rate of advance, constitutes 60-80 m of advance of the face). The daily interval of observations was shifted as the face advanced. The correlation functions were estimated with an error of 10%. The functions were calculated on the "Razdan-2" and "Minsk-32" computers at the Skochinski Institute of Mining.

First we found that on the average, the principal periodicities of the disintegration process (reflecting the caving intervals of the main roof) are different for different seams. Then we found that the periodicity of descent can also change in the same section of a given seam as the face advances. Thus for the "Devyatka" seam in 1967 the mean period between roof settlements was 7 days (14 m of advance), whereas in 1968 it was 9 days (18 m). For the "Zolotarka" seam in 1967-1968 the period of settlement varied over an even wider range from 10 to 16 days. A more detailed investigation of this is described in [8].

Besides the main system of maxima, the correlation functions of the noise level have shorter-period components. Thus in the "Devyatka" seam in 1967, as well as the main periodicity of 7 days, there was also a marked periodicity of 3 days. In the "Zolotarka" seam we also observed a noise periodicity of 2 days, which was apparently due to the behavior of the immediate roof. We sometimes observed a third periodic component. It would seem that the presence of several clearly marked periodic components in the correlation functions of the noise levels indicates bed separation of the roof rocks into layers each of which has its own settlement period. Over a long time, the correlation functions of the noise level may remain unaltered, may change smoothly from one periodicity to another, or may alter suddenly. The latter is often observed when the working intersects a geological fault. This variable behavior of the correlation functions of the noise level indicates a very complicated, variable behavior of the shifting roof rocks, possibly due to complex lithological variations in the rock of the coal measures, to possible thinning-out, facies variations, and geological faults in the overlying cross section, and finally to the influence of overlying workings.

Further correlation analysis of the noise level was aimed at elucidating the features of the correlation functions in the zones where dynamic phenomena actually occurred and in the zones where they did not occur. We found that in the hazardous zones where dynamic phenomena such as bursts and main-roof settlements occurred, the noise level correlation functions have a specific form. They have a long-period component with a period of 24-25 days, which corresponds to a long hanging rock cantilever. The same form of the function is also observed ahead of geological faults in which dynamic phenomena are observed as they are crossed. On the other hand, in zones of the seam where dynamic phenomena did not occur or where they were of the spillage type, the periodicity of the correlation functions is much shorter—4-8 days; this is also observed in zones of high noise level, which are regarded as hazardous according to the present method of routine seismoacoustic prediction of burst hazard [5]. It appears, then, that a high noise level, reflecting an anomalously high rate of crack formation in the coal, is only one of the necessary signs of burst hazard. Another is high pressure on the face zone of the seam. In the absence of high pressure in the face zone, the possibility of gas bursts is removed by natural degassing through the formation of a system of fissures. The dynamic phenomena are reduced to coal spillage.

These laws confirm the above hypothesis that dynamic phenomena are a very probable consequence of high loads on the face zone of the coal seam during the period preceding breakaway of the rock cantilever (settlement of the main roof), and are also a consequence of sudden load relief of the face zone and sudden shifting of the maximum on the rock pressure distribution deeper into the coal during and immediately after the settlement. This leads us to the conclusion that dynamic phenomena such as bursts and coal falls occur when the hanging cantilever of main roof rock creates large loads on the face zone of the coal seam so that the face cannot remain stable as the stresses increase.

These features offer possibilities for further improvement to present methods of routine seismoacoustic prediction [5] in the direction of cutting the length and reducing the number of the zones designated as hazardous: this is important because it will economize on the high costs of antiburst measures in nonhazardous zones. We must, of course, continue to take all possible steps against bursts in undoubtedly hazardous zones, or more precisely in undoubtedly hazardous periods of working of a seam.

The ideas in this article can also be used in the practice of local or even regional geological prediction of burst hazard: from the presence, in the geological structure, of strata lying above worked coal seams which are strong and liable to hang, we can indirectly judge the proneness of a seam to dynamic phenomena. However, we must admit that this assessment may be merely preliminary, because the real process of rock movement during