Characteristic Analysis of Surface Subsidence in Deep Mining

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Abstract

Based on the monitoring data of surface subsidence in 230 mining area of Tangkou Coal Mine, the surface dynamic subsidence characteristic under deep mining subsidence and the maximum subsidence velocity were analyzed. The results showed that: in the deep mining that exceeds 300 meters, the ground surface settlement is still large, the outer boundary of subsidence basin appears the phenomenon of ground bounce and raise. The subsidence velocity of measuring points was affected greatly by mining, the high peak was basically synchronous with the mining time of working surface, surface subsidence appeared the phenomenon of concentration and slowness obviously. If only consider the effect of time, the sinking of measured point at any time can be obtained by fitting the trinomial.

Keywords: deep mining; surface subsidence; maximum sink point; subsidence velocity; surface movement law

With coal resources being mined continuously, the coal resources of the shallow, middle range become less and less, while the pace of development of mine to deep mining is accelerating, therefore, deep mining has become an inevitable course of the production of coal mine [1]. Under the condition of high ground stress and the complex occurrence environment of rock layer, there is a big difference between the deep mining and the shallow mining, besides the surface subsidence characteristics have obvious differences compared with the shallow. In recent years, with the development of computer technology, the deformation of surface movement can be analyzed by simulation , but the process of mining conditions tend to be simplified during the simulation, which leads to the deviation between the expected result of surface movement deformation with the actual one [2-3], so setting up mobile station for actual monitoring is not of replacement in the earth's surface [4-5], especially in deep mining conditions, the rock movement data is little, the deformation mechanism of surface movement is not the same compared with the shallow one, by the analysis of the data of strata movement gained in the process of deep mining, we can find out its regularity, which has important guiding significance for "three under" mining of deep coal.

1. Project Summary

There are eight working faces in 230 mining area of Tangkou Coal Mine, and its mining elevation of coal seam is-740~-1040m, its mining depth is 780 ~ 1080 m. The 2301 ~ 2306 working faces belong to the ones of strip mining, the mining width is 120 m (including along the groove width),and the preserved width is 100 m; The inclined length of 2307 working face is 210 m, this of 2308 is 200 m, and both those two working faces are the mining faces . The coal seam of 3 is the main mining one, its

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thickness is between 1.70 ~ 3.80 m, 2.90 m on average, and its dip is about 8 °or so. The immediate roof of working face is brown grey mudstone, and the average thickness is 3.0 m, belonging to unstable roof; The main roof is grey ~ gray sandstone, and the thickness is 6.6 ~ 12.0 m, 6.3 m on average, belonging to the roof of better stability. We adopt longwall retreating mining, a full-seam comprehensive mechanized coal mining, the management of roof is all caving method, and the mining situation of every working face is shown in figure 1.

2. Monitoring Conditions of Ground Strata Movement

In order to study the basic surface movement law, before the working face begins to mine, according to the actual surface circumstance of 230 mining area, we set up four monitoring lines, among them there are two broken in the process of monitoring, the remaining are in good condition. L1 guider line located in the south of the mining area is about 1610m in length and consists of 61 measured points, and the distance of every measured point is 20 to 50 m; L2 guider line is located in the north of the mining area, about 1785m long, is made up of 35 measured points, the space between measured points is 50m on average. The relationship between guider line and working face is shown in figure 1.

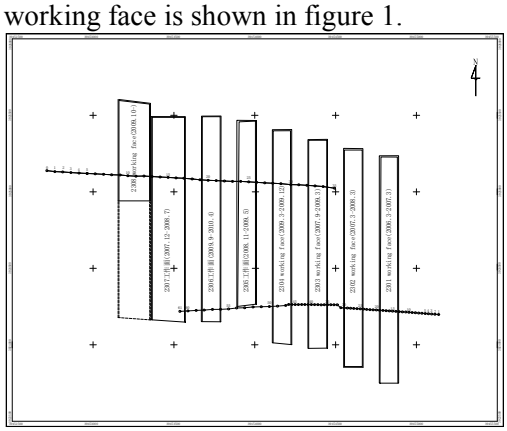
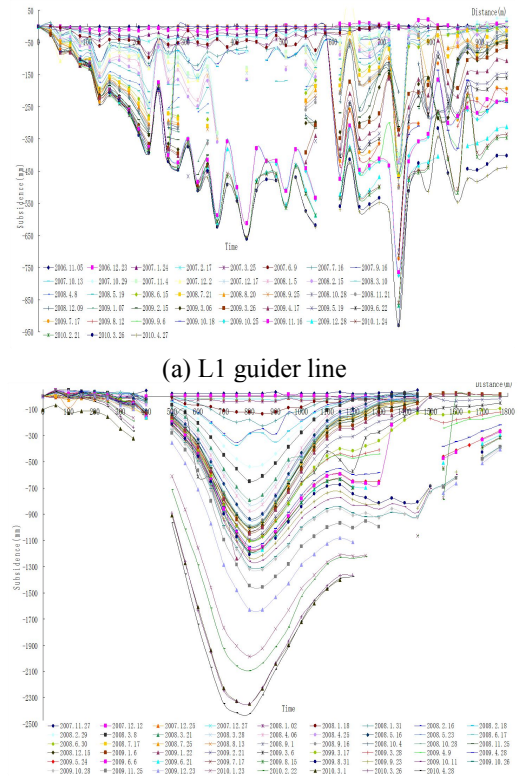


Fig. 1 The relationship between guider line of surface rock movement and working face

The monitoring of L1 guider line in 230 mining area started on November 5, 2006, ended on April 27, 2010, a total of monitoring was 43 times, and its surface dynamic subsidence situation was shown in figure 2 (a); The monitoring of L2 guider line began on November 27, 2007, ended on April 28, 2010, a total of monitoring was 53 times, and its surface dynamic subsidence situation was shown in figure 2 (b).



(a) L1 guider line

(b) L2 guider line

Fig. 2 Dynamic subsidence curves of surface in 230 working area

3. Surface Subsidence Characteristics

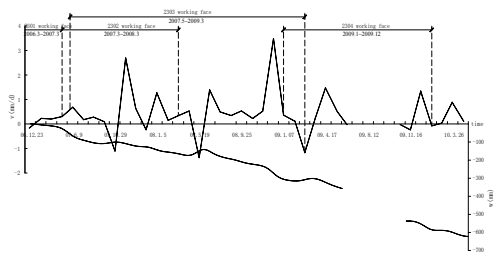
L1 guider line has 48 measured points having monitoring data, respectively above 2301, 2302, 2303, 2304, working face, while the rest of the measured points is damaged by man-made, without monitoring data; Some are filled for the damaged measured points in the process of monitoring in L2 guider line, thus the integrity of the measured point data is ensured, the measured points are

respectively above 2303, 2304, 2305, 2306, 2307, 2308 working face. Based on the dynamic subsidence curve of L1 guider line, we can notice that the curve is not smooth, there are mutations points and they exist respectively in 13, 16, 18, 20, 24, 27, 38, 37, 41 measured points, and these measured points are in butt entry or the middle of mining area which rock stratums are in fractured or caving condition. 2301, 2302, 2303, 2304 working faces in inclined direction belong to the ones of inadequate mining, and the mining time of each working face is various, therefore the surface subsidence curve present a jagged one, the maximum subsidence value is 930 mm, the maximum differences from curve of fracture is 353 mm, which is relatively small, and large sinkholes are not found in the ground. Due to the effect of 2307, 2308 mining faces in L2 guider line, the subsidence curve is relatively smooth, the curve mutation phenomenon is not obvious, and the curve looks like a kettle because of not achieving full mining conditions. From the dynamic changes of the surface subsidence curve, we can see that the formation of the ground subsidence is a process of time and space, as the working face is in mining condition, the monitored subsidence curve can form the final subsidence basin in the earth's surface through continuous changing adjustments. The surface subsidence commonly has the characteristics of deep mining in the process of mining of 230 mining district: The range of surface subsidence is big (the maximum affected range reach more than 700 m on the inclined direction of working face), the corresponding mobile deformation value of basin edge decreases; The fully mining degree is affected and surface movement and deformation value is small when single working face is in working condition, while many working faces are in continuous mining condition, surface movement and deformation value can achieve the extremum of geological and mining conditions. We found that under the condition of the ratio of depth to thickness more than 300, there were still large subsidence after mining in strip and the whole working face by monitoring, which were obviously different from the surface movement law of shallow mining and the guider line monitored that the outer boundary of subsidence basin appeared the phenomenon of ground bounce and raise.

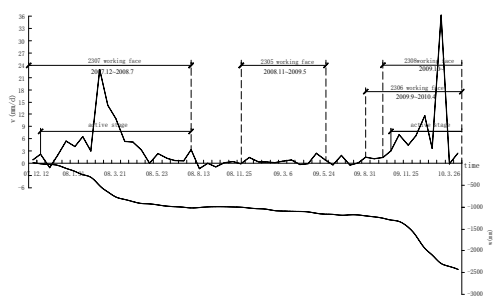
4. The Maximum Surface Subsidence Velocity

The maximum surface subsidence velocity is an important parameter reflecting the intensity of surface movement deformation, and its value has a direct impact on mining under buildings and railways. The biggest sinking point 29 measured point of L1 guider line is in the position above 2302 working face, mainly influenced by mining of 2301, 2302, 2303, 2302 working face, while the biggest sinking point 16 measured point of L2 guider line is in the position above 2307 working face, mainly influenced by mining of 2308, 2307, 2306, 2305 working face, and the relationship between subsidence velocity and curve and the working face at the maximum subsidence point is shown in figure 3. The biggest sinking point of the two guider line affected by mining of working face is similar, the first sinking velocity peak value of the 29 measured point of L1 guider line was 2.67 mm/d, appeared in 2302, 2303 working face during mining, at the end of mining of 2302 working face in March 2008, the distance from 2303 working face to 29 measured point was about 750 m, which had a less effect on the measured point, thus sinking speed peak value was caused by the 2302 working face; The ground maximum sinking value was 167 mm after mining

of the second strip working face, the subsidence is gentle, and there is no big fluctuation; The second sinking velocity peak of 29 measured point appeared in the 2303 working face during mining, its speed was 3.50 mm/d, the sinking value was 300 mm, monitored time was in December, 2008, which was the time 2303 working face carried forward near measured points, we were sure that the peak of subsidence was caused by mining of 2303 working face; 2304 working face was far away from 29 measured point, the maximum sinking value of measured point of 2304 working face reached a maximum 623 mm during mining, but the maximum sinking velocity was 1.45 mm/d, the mining of working face had a little effect on measured points.



(a) 29 measured point of L1 guider line



(b) 16 measured point of L2 guider line

Fig. 3 The relationship between subsidence velocity and curve and the working face at the maximum subsidence point

We can see surface subsidence velocity is regular change from sinking velocity diagram of the measured point, the subsidence velocity increased when the measuring point was affected by coal mining of working face, otherwise the subsidence velocity was small, surface subsidence appeared the phenomenon of concentration and slowness obviously, and the sinking speed changed largely. From subsidence velocity corresponding to mining of working face, the peak of sinking velocity didn't lag mining time of working face, basically synchronous with the mining time of working surface, the influence of underground mining on the surface didn't slow down with mining depth increasing, which established some relevance by the rate and change of surface movement deformation with the frequency and intensity of energy release of rock bursts occurred in underground [6-7] , thus we could provide a basis of forecast in advance for rock bursts occurred in underground .

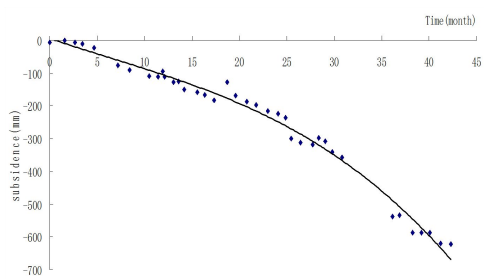
Through analyzing the subsidence curve, in the case of only considering time element, the value of subsidence of the measuring point can use trinomial W (t) = at3 + bt2 + ct + d at any time by fitting.

The biggest sinking point 29 measured points, 16 measured point of L1 and L2 guider line, the fitting formula of subsidence value and time at any time are:

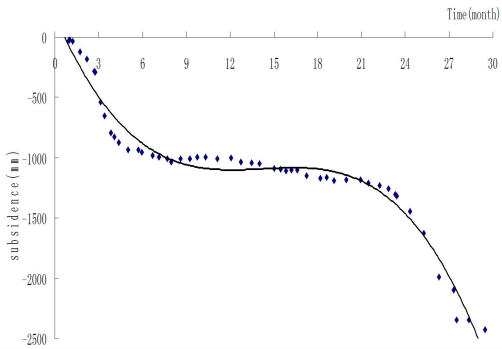
W (t) = 0.0062 + 0.1166 t2 t3 0.1166 t + 5.9533 (R2 = 0.9857) (1)

W (t) = 0.4695 + 20.069 t2 t3 20.069 t + 174.49 (R2 = 0.9704) and (2)

The fitting curve of subsidence value of points and the mining time is shown as figure 4, the fitting correlative coefficient is over 0.97 and the fitting degree is higher, which can satisfy the requirement of engineering.



(a) 29 measured points of L1 guider line



(b) 16 measured points of L2 guider line

Fig. 4 Relationship between subsidence volume and mining time

5. Conclusions

(1)Under the condition of mining inadequately in many working faces and mining time being not synchronized, the monitored surface subsidence curve is not smooth, it is serrated, and there are mutation points of surface subsidence in overlying rocks fracture or caving of working faces.

(2) The surface subsidence of this region has characteristics of big influence scope and small deformation of general deep mining, the surface subsidence quantity is still large after mining of working face and the outer boundary of subsidence basin appeared the phenomenon of ground bounce and raise under the condition of the ratio of depth to thickness over 300.

(3) The rule changes of the sinking speed of maximum ground subsidence point and the peak of the sinking speed is basically with mining time of working face in time synchronization, surface subsidence appeared the phenomenon of concentration and slowness obviously.

(4) Through analyzing the subsidence curve, in the case of only considering time element, the value of subsidence of the measuring point can obtain by using trinomial at any time by fitting, practice shows that the fitting degree is higher, which can satisfy the engineering requirement.

6. Reference

[1] XIE He-ping, PENG Su-ping, HE Man-chao. Deep Mining Basic Theory with Engineering Practice. Beijing: Science Press, 2006

[2]YU Bao-hua, ZHU Wei-bing, XU Jia-lin. Numerical Simulation of Surface Subsidence Induced by Deep Mining [J].Journal of Mining & Safety Engineering,2007,24(4):422-425.

[3]PENG Lin-jun, ZHAO Xiao-dong, LI Shu-cai. Simulating Research on Rules of Surface Subsidence Due to Deep Mining [J]. Rock and Soil Mechanics, 2011, 32(6):1910-1914

[4]LI Chun-yi, CUI Xi-min, GUO Zeng-zhang, ect. Surface Subsidence Characteristics Due to Deep Mining with Thick and Broken Overburden [J]. Coal Engineering,2008, (12):94-97.

[5]LIU Yi-xin, DAI Hua-yang, JIANG Yao-dong, ect. Study on Surface Movement Law above Underground Deep Mining under Thick Unconsolidated Overburden Strata [J]. Coal Science and Technology,2013, 41(5): 117-120.

[6]WANG Li1, ZHANG Xiu-feng. Correlation of Ground Surface Subsidence Characteristics and Mining Disasters under Super-thick Overlying Strata [J]. Journal of China Coal Society,2009, 34(8):1048-1051.

[7]GUO Wei-jia, KONG Ling-hai, CHEN Shao-jie, etc. Correlation between Rock Burst and Movement of Strata and Ground Surface [J]. Rock and Soil Mechanics, 2009, 30(2):447-451.

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