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Research Article

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Research on Causes of Impact Rock Pressure in Mining in High Stress Concentration Area

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Abstract Rock burst is one of the coal and rock dynamic phenomena in coal mining, which may cause accidents in coal mines, roof collapse, floor heave, or disasters in adjacent coal mines. With the increase of mining depth, rock burst caused by coal and rock dynamic disasters has become increasingly prominent. At present, the influence of rock pressure is more and more serious, and the number of occurrences is more and more. Therefore, the prediction and prevention of impact in deep mining process can not wait. According to the research status of rock burst in high stress concentration area, the influence of mining depth on stress distribution is analyzed, and appropriate measures to reduce the occurrence of rock burst are taken to ensure the safety of coal mine production. Therefore, it is necessary to carry out the research of this paper.

Keywords rock burst; high stress; pressure relief; concentration area

Mining engineering is a large-scale engineering activity that workers are engaged in deep underground. With the continuous increase of resources development intensity, mining is developing deeper underground. At present, China's production demand is very large, and the depth of coal mining is getting deeper and deeper. Because of the increasing pressure in deep mines, the occurrence times and hazards of rock burst are gradually increasing, such as accidents in coal mines, roof collapse, floor heave in sheets, or disasters in adjacent coal mines. These serious dynamic disasters can cause a large number of casualties, damage underground equipment, and also lead to paralysis of ventilation system, and even more serious can cause surface subsidence. And bring great harm to production. Therefore, it is urgent to study the prediction and control of mine pressure in deep mines, and we must take it seriously.

Since the 1960s, rock researchers have gradually realized the phenomenon of crack propagation caused by instability and deformation location. The mechanical properties and fracture of rock anisotropy under external loads should be closely related to the evolution of stress field. The mechanism of rock burst is very complicated. Many scholars have put forward corresponding preventive measures, such as the control of exhaust gas in Panyishan [1-2], the measures of coal seam explosion risk can reduce gas and avoid rock burst; Jiangyao [3] exploring the blasting vibration of roadway power loss, exploring the stability of flexible support structure can effectively absorb vibration energy and reduce roadway deformation, and the U-shaped telescopic steel support is excellent. In the anchor net support; Qiqing newly proposed [4-5] hard roof rock-breaking blasting controlled blasting technology; Sanxingyan "Three Soft" Coal Mine in eastern Xuzhou, put forward reliable support pressure, so that it slowly releases elastic energy in the soft rock impact of mining area, effectively reducing the impact trend of coal seam weakness. Su Chengdong [6] predicted and controlled the impact pressure of deep-buried high-stress roadway in Pingdingshan No.12 Coal Mine, and adopted shallow-hole blasting pressure slow-release measures to effectively eliminate and reduce the impact ground pressure; Professor Dou Linming [7-9] put forward the theory of strength weakening of impact ground pressure, which used the method of relieving blasting and achieved obvious results; Pan Liyou [10] put forward the theory of defect energy release for reducing the impact ground pressure. The stress effect of some low coal pillars and the continuous release of energy can reduce the occurrence of rock burst. In a word, high stress is the necessary condition to cause rock burst.

1. Theoretical analysis of the relationship between mining depth and stress

It is assumed that the surrounding rock is homogeneous, isotropic, in a two-way unequal pressure stress field, and the roadway section is circular. Consider the plane strain. The roadway analysis model is shown in Figure 1.

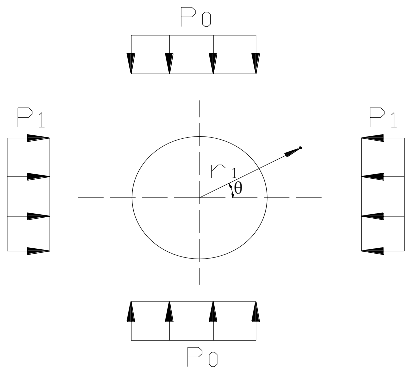

Figure 1: Roadway Analysis Model

According to the theory of elasticity, the stress in the coal and rock mass around the roadway is as follows:

$$\sigma_r = \frac{\gamma H}{2}(1+\lambda)(1-\frac{r_1^2}{r^2}) - \frac{\gamma H}{2}(1-\lambda)(1-4\frac{r_1^2}{r^2}+3\frac{r_1^4}{r^4})\cos 2\theta \quad (1\text{-}1)$$

$$\sigma_\theta = \frac{\gamma H}{2}(1+\lambda)(1+\frac{r_1^2}{r^2}) + \frac{\gamma H}{2}(1-\lambda)(1+3\frac{r_1^4}{r^4})\cos 2\theta \quad (1\text{-}2)$$

Formula: expressed as radial stress, expressed as tangential stress, is the bulk density of overlying strata, mining depth, lateral pressure coefficient, roadway radius.

Formula (1-1) and Formula (1-2) show that for a given lateral pressure coefficient, the coal and rock mass in any direction of the roadway increase with the increase. In particular, for circular roadways under uniform confining pressure, near the roadway, the radial stress 0. At this time, with the increase of mining depth, when the ultimate bearing capacity of coal and rock mass is reached, the coal and rock mass will be destroyed, thus creating conditions for the occurrence of rock burst.

For underground coal mining face, it can not be analyzed by circular hole after a certain distance is pushed through the cutting hole. At this time, it can be approximated as a flat elliptical hole for analysis [11]. The circular tunnel in Fig. 1-1 is replaced by an elliptical chamber. According to elasticity, the tangential stress around the elliptical chamber is as follows:

$$\sigma_\theta = \gamma H(\frac{m^2\sin^2\theta + 2m\sin^2\theta - \cos_2\theta}{\cos^2\theta + m^2\sin^2\theta} + \lambda\frac{\cos^2\theta + 2m\cos^2\theta - m^2\sin^2\theta}{\cos^2\theta + m^2\sin^2\theta} \quad (1\text{-}3)$$

In formula: m is the ratio of long axis to short axis of elliptical chamber.

Formula (1-3) also shows that the tangential stress of coal and rock mass around the chamber increases with the increase. Once the ultimate bearing capacity of coal and rock mass is reached, the failure of coal and rock mass may cause impact.

Because the sudden release of energy gathered in the coal and rock mass around the underground or working face is called rock burst, it is necessary to analyze the situation of elastic energy stored in the coal and rock mass while clarifying the relationship between mining depth and stress [12].

In theory, in the gravity stress field with mining depth H and without mining influence, the stress of coal seam is as follows:

$$\sigma_1 = \gamma H \quad (1\text{-}4)$$

$$\sigma_2 = \sigma_3 = \frac{\mu}{1-\mu}\gamma H \quad (1\text{-}5)$$

The elastic energy accumulated by volume deformation in unit coal seam is as follows:

$$U_v = \frac{(1-2\mu)(1+\mu)^2}{6E(1-\mu)^2}\gamma^2 H^2 \quad (1\text{-}6)$$

The elastic energy accumulated by shape deformation is:

$$U_f = \frac{(1-2\mu)^2}{6G(1-\mu)^2}\gamma^2 H^2 \quad (1\text{-}7)$$

If the influence of tectonic stress is considered, the normal stress of rock mass is as follows:

$$\sigma_2 = \gamma H \quad (1\text{-}8)$$

$$\sigma_1 + \sigma_3 = 2\xi\sigma_2 \quad (1\text{-}9)$$

In the formula, it is the ratio of average horizontal stress to vertical stress.
The volumetric energy of coal and rock mass per unit volume is as follows:

$$U_v = \frac{(1-2\mu)(1+2\xi)^2}{6E}\gamma^2 H^2 \quad (1\text{-}10)$$

If all the deformation energy in coal seam is used for the plastic deformation of coal, the volumetric deformation energy is consumed to crush coal body and make it move, the physical meaning of Formula (1-7) and Formula (1-10) is that the elastic energy stored in coal and rock mass is related to the stress state, and the increase of mining depth is proportional to the square of mining depth. Under the influence of coal mining, the stress redistribution occurs in the coal seam working face, and the stress concentration factor K can reach 3 5. High stress can lead to the increase of elastic energy accumulated in coal seam, and high stress can lead to the increase of elastic energy accumulated in coal and rock mass by an order of magnitude.

2. Numerical simulation analysis of depth and stress distribution

The influence of different mining depth on stress distribution of working face is simulated by 50 m advance of working face. The model is 150 m long and 41 m high. The influence of stress concentration at mining depth of 400 m, 600 m, 800 m and 1000 m is calculated.

2.1. Mining Depth 400m

The supporting stress distribution in front of the working face is shown in Fig. 2.

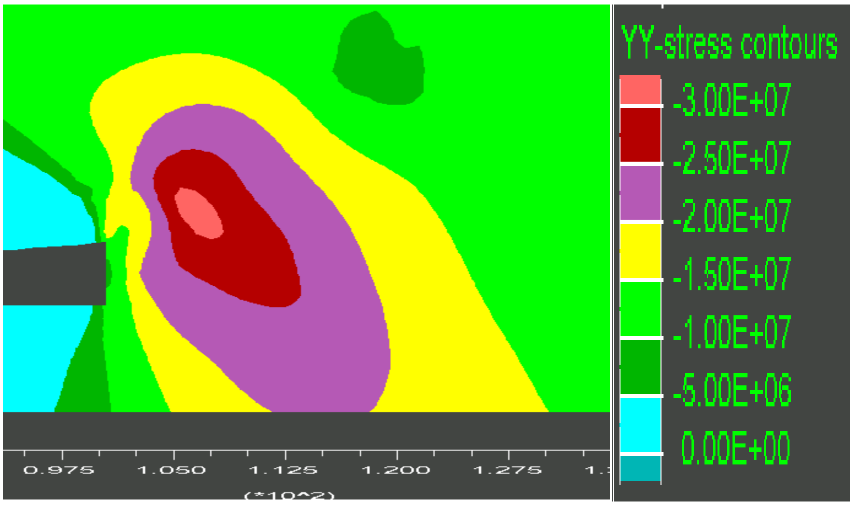

Figure 2: Depth of 400m

At the moment, the maximum supporting stress at the forefront of the working face is 27.3 MPa, the maximum stress concentration factor is 2.73, and the stress peak is 10 m from the coal wall of the working face.

2.2. Mining Depth 600m

The distribution of the supporting stress in front of the working face is shown in Fig. 3.

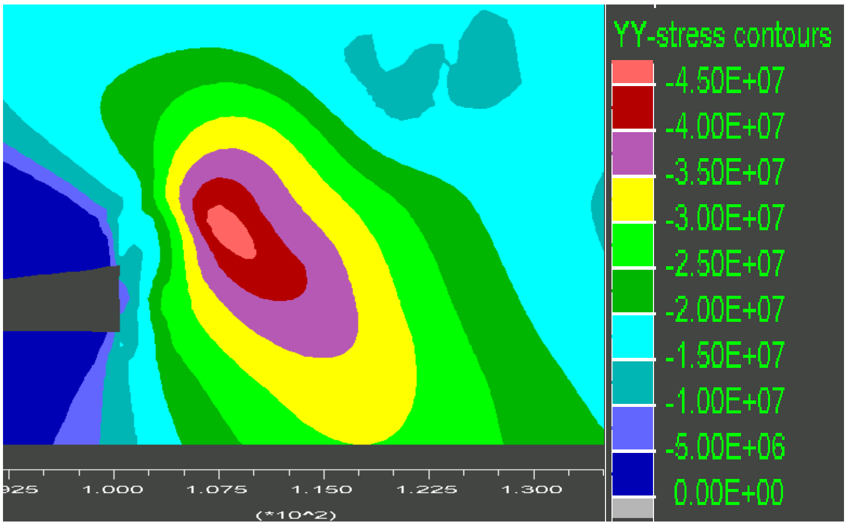

Figure 3: Depth of 600m

At the moment, the maximum supporting stress in front of the working face is 40.8 MPa, the maximum stress concentration factor is 2.72, and the peak stress is 11 m away from the coal wall of the working face.

2.3. Mining Depth 800m

The supporting stress distribution in front of the working face is shown in Fig. 4.

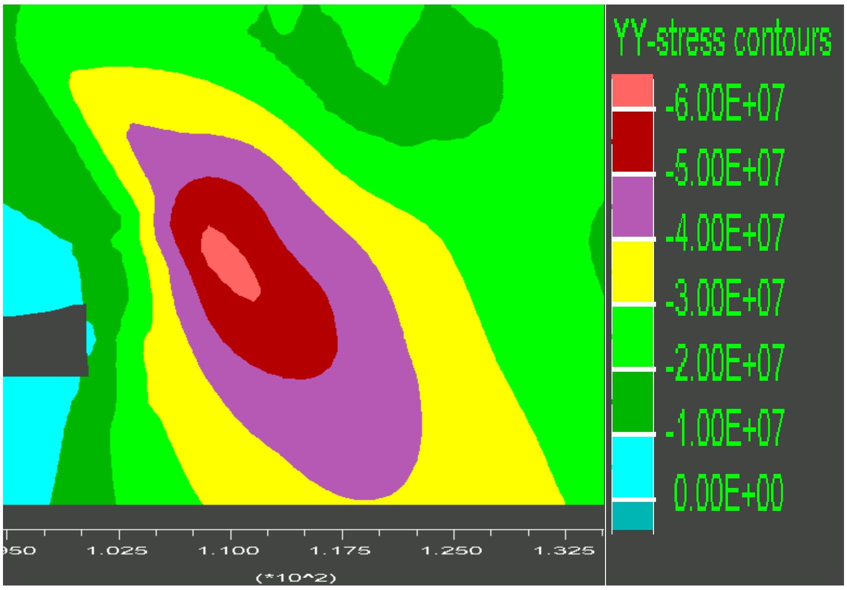

Figure 4: Depth of 800m

At the moment, the maximum supporting stress in front of the working face is 55.4 MPa, the maximum stress concentration factor is 2.77, and the peak stress is 12 m away from the coal wall of the working face.

2.4. Mining Depth 1000M

The supporting stress distribution in front of the working face is shown in Fig. 5.

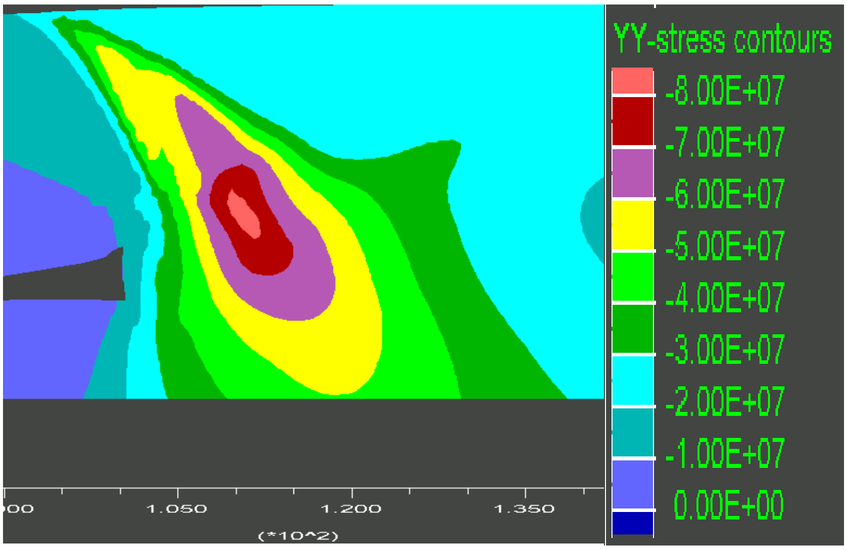

Figure 5: Depth of 1000m

At this moment, the maximum supporting stress in front of the working face is 72.3 MPa, the maximum stress concentration factor is 2.89, and the peak stress is 12 m away from the coal wall of the working face.

In conclusion, the mining depth has a great influence on the stress distribution in front of the working face. With the increase of mining depth, the maximum supporting stress will also increase, and the maximum stress concentration factor will increase. The peak stress and the distance between the working face will also increase accordingly.

3. Statistical Analysis of the Impact of Mining Depth on Rock burst

The occurrence of rock burst is closely related to mining depth. The incipient depth of dynamic disasters in some coalfields in our country and the incipient depth of rock burst in several other important coal-producing countries are shown in Tables 1 and 2.

Table 1: Statistics Table of Initial Depth of Rockburst in Some Mines of China

Mine name	Originating depth H_0(m)	Mine name	Originating depth H_0 (m)
Tianchi mine	240	Longfeng mine	300
Mentoug gou mine	200	Yanshi Tai mine	235
Fangshan mine	520	Huafeng Mine	710

Table 2: Statistics of Initial Depth of Rockburst in Mines of Some Foreign Countries

Country name	Originating depth H_0 (m)	Country name	Originating depth H_0 (m)
South Africa	300	Poland	240
Canada	180	Germay	300
Soviet Union	200	Britain	600

From Table 1, it can be seen that the initial depth of rock burst in coal mines in China is 200-710 m, with an average of 450 M.Relevant statistics show that the frequency and intensity of rock burst will increase with the increase of mining depth. The relationship between mining depth and rock pressure is shown in Fig. 3. Considering the limit of safety, it can be determined that no rock burst will occur when the depth is not more than 350m. When the depth of 350 < H is less than or equal to 500m, the risk increases gradually to some extent. Starting from 500m, with the increase of mining depth, the risk of rock burst increases rapidly. From the graph, when the mining depth is 800m, the impact index Wt = 0.57 is 14 times higher than that of 500m (Wt =

0.04). From the trend of Wt = f (H) curve, when the mining depth is very large (1200 1500m), the gradient of influence index will decrease, but its value will be very high.

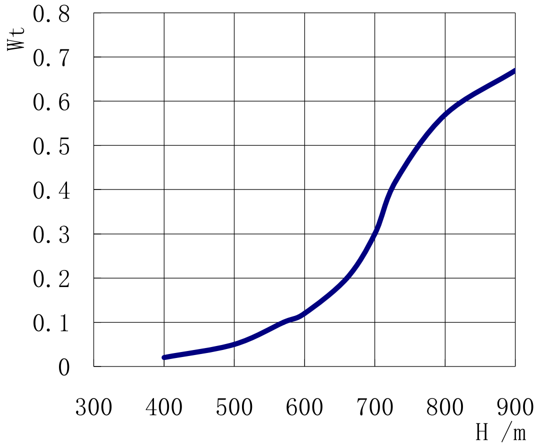

Figure 6: Relation between mining depth and rock burst in Poland

The situation of some coal mines in China is similar. The relationship between mining depth and occurrence frequency and intensity of rock burst in some mines in China is shown in tables 3 and 4.

Table 3: Relation between mining depth and occurrence frequency and intensity of rock burst in Tianchi Coal Mine, Chongqing

Number and intensity of rock burst	Mining Depth (m)		
	200~400	**400~500**	**500~600**
Number of occurrences	4	9	9
Incidence (%)	2	49	49
Occurrence strength	5.8	180	1000

Table 4: Relation between mining depth and occurrence frequency and intensity of rock burst in Yanshitai Coal Mine

Number and intensity of rock burst	Mining Depth (m)			
	200~300	**200~300**	**400~500**	**500~600**
Number of occurrences	19	18	32	43
Incidence (%)	17	16	28	39
Occurrence strength	2636	795	590	1443

Tables 3 and 4 show that under the current conditions of coal mines in China, with the increase of mining depth, the occurrence frequency and intensity of rock burst also increase, and the threat of rock burst to safety production is increasing.

4. Conclusion

- The theoretical analysis of the relationship between mining depth and stress shows that high stress can increase the elastic energy accumulated in coal seam, and high stress can increase the elastic energy accumulated in coal and rock mass by an order of magnitude. Once the bearing capacity of coal and rock mass is broken through, the coal and rock mass will be destroyed and the impact may be triggered
- Through the numerical simulation analysis of mining depth and stress distribution, it can be seen that the stress distribution in front of the working face is greatly affected by mining depth, the maximum supporting stress will also increase with the increase of mining depth, the maximum stress concentration factor will also be the same, and the stress peak value and the distance between the working face will also increase to some extent.
- According to the mine depth statistics and impact effect analysis, under the condition of coal mines in China, the number and intensity of rock burst increase with the increase of mining depth, and the threat of rock burst becomes more and more serious.

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