The Numerical Simulation of The Influence from Fault Dip Angle on Coalface Pressure

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Abstract: This paper simulated the effects of faults on mine pressure distributions in coal mining process by using UDEC4.0 numerical simulation software. The rock burst mechanisms of normal faults and thrust faults were analyzed first. After that, the working face of front abutment pressure peak values and distributions were studied by the initial model during the working face is mined in the hanging wall and footwall of fault. At last, when the distance between working face and fault is 20 meters, the working face front abutment pressure peak values variation under different fault dip angles was researched. It turned out that: When the working face is mined in the footwall of fault, the working face front abutment pressure peak values firstly increase with the increases of fault dip angles. When the fault dip angle is about 70 °, the front abutment pressure peak value reaches the maximum of 73.57 MPa. When the working face is mined in the hanging wall of fault, the working face front abutment pressure peak values are roughly into a rising trend with the increases of fault dip angles.

Key words： Fault dip angles, Front abutment pressure, UDEC numerical simulation, Fault Hanging wall, Fault Footwall

Fault rock burst in coal mine is a natural disaster, which influence factors are extremely complex[1-3].Long term underground mining practices proof that the analysis of the stress distribution and stress values near faults is the base for prevention and control rock burst. In general, high stress areas are more likely to accumulate elastic properties.

In certain exploitation region, the region rock burst hazard degree can be obtained by analyzing and determining the stress distribution and stress concentration degree.Therefore, it is effectively to prevent rock burst occurrence and eliminate the effect of impact risk on the recovery work by taking corresponding preventive relief measures in time[4-5].

1.Mechanism analysis of rock burstinduced by faults

There are mainly two kinds of faults in mine production , normal fault and thrust fault. According to geological mechanics, these two kinds of faults have different formative factors and distinctive mechanisms inducing rock burst.

1.1 Thrust fault

Thrust fault is formed mainly by horizontal compression[5]. Theformation process of it[6], as shown in Fig. 1, can be described as: (a) high horizontal stress extrusion forms anticline tectonic, (b) the central of a wing twists under the combined actions of the horizontal stress continuous extrusion and the torque caused by two inhomogeneity horizontal stress, (c) horizontal stress continuous extrusion and shear stress produced by twist make the fracture dislocation and then form a thrust fault.
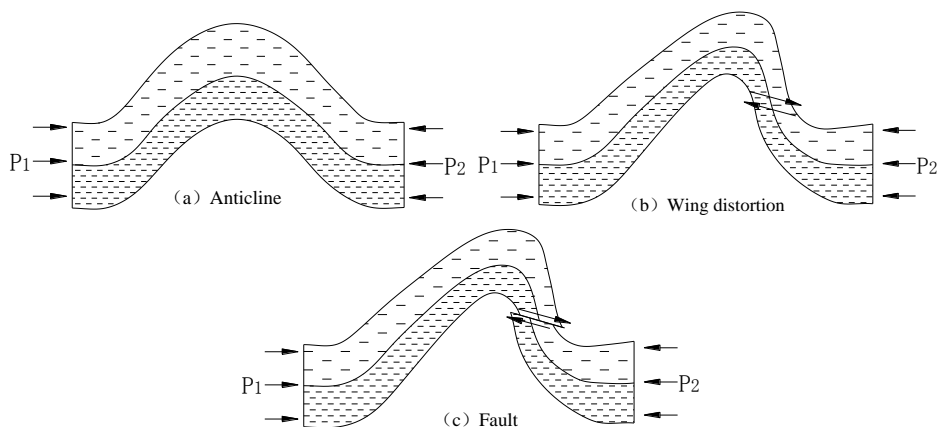
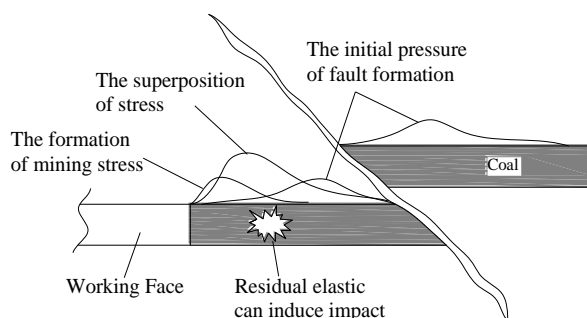Fig. 1: Formation of thrust fault

Fig. 2: Schematic diagram of the mechanism of coal burst induced by thrust fault

Strata interior accumulate a large amount of elastic properties by extrusion effect during the formation of thrust faults. A large part of elastic energy is released because of the plastic yield and rock fracture, but still there are some elastic energy and residual stress. The thrust fault induced rock burst mechanism consists of two parts, stress superposition and elastic properties further release, as shown in Fig. 2.

1.2 Normal fault

The formation of normal fault is affected by both lateral tension and vertical extrusion[7], where the vertical extrusion is the main influencing factor. Normal-fault is formed by rock tensile and with few energy accumulation in interior, so the rock burst mechanism induced by it is mainly the stress superposition of abutment pressures formed by fault and mining, which is shown in Fig. 3.
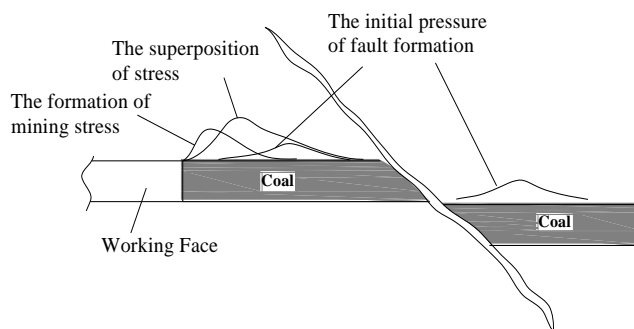

Fig.3: Schematic diagram of the mechanism of coal burst induced by normal fault

From the above analysis, thrust fault is more likely to induce rock burst than normal fault in the same geological conditions, so numerical simulation was studied only on the background of thrust fault.

2. The numerical simulation of fault dip angle's effect on stope underground pressure

In order to analyze the influence of fault dip angle on the working face front abutment pressure peak, the initial model with 30 °dip angle is firstly set up. Then the working face front abutment pressure distribution is studied respectively when the distances between working face and fault are 10, 20, 30, 40, 50, 60 meters during the working face is mined in the hanging wall and footwall of fault. On this basis, the most dangerous region of fault impact is got and then the effect of different fault dip angles on the most dangerous area of impact is studied.

2.1 The establishment of the initial model

Liang Baosi 3301 working face adopts the strip fully mechanized top coal caving mining with the average working face depth of 800 meters and the average coal thickness of 5 meters. There is a thrust fault with a fault throw of 5 meters in front of advancing working face. The model takes this as the background, as shown in Fig. 4. The model size is 400 meters × 110 meters with12 layers strata, the fault structure plane in the middle,10 meters fault fracture zone horizontal distance and 5 meters fault throw. The material constitutive model is the Mole - Kulun model.
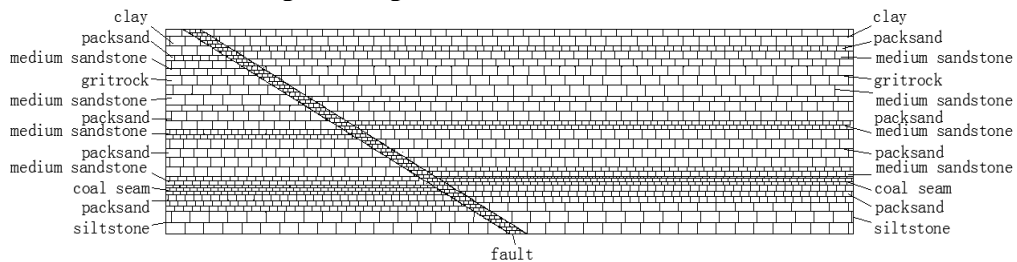

Fig. 4: Numerical simulation of initial model

The boundary conditions of this model are:
  (1) model Z direction upper boundary is free surface;
  (2) the vertical load is applied to simulate overlying strata gravity load;
  (3) model Z direction bottom boundary limits vertical displacement;
  (4) the horizontal displacement of Model left and right boundaries is fixed;
  (5) the depth of the model is about 800m with 21.17MPa vertical stress applied at the upper boundary and 10m/s² gravity acceleration.

2.2 The influence of mining on working face abutment pressure

When the distances between working face and fault are 10, 20, 30, 40, 50, 60m spectively during the working face is mined in the footwall of fault, these working face front abutment pressure distributions are shown in Fig. 5 and these working face front abutment pressure peak values are shown in Table 1.

As can be seen from Fig. 5, when the distances between working face and fault are 40, 50, 60m, these three curves of working face abutment pressure consistent with each other, that is to say fault has little effect on working face abutment pressure. When the working face is 20

meters away from the fault plane , the influence of fault on the abutment pressure is strongest, where the abutment pressure peak value is 60.07 MPa the stress concentration coefficient 2.93. When the distance between working surface and fault is less than 10 meters, the stress on coal is far more than the ultimate strength of coal so that coal plastic is damaged, pressure-bearing capacity is reduced, the impact risk enhances. Liangbaosi mine field measurements indicate that the front abutment pressure peak position away from the coal wall is generally 2~3.5 times the mining height and the stress increased coefficient is 2.5~3. The numerical simulation results areconsistent with field measurements experience, so them can accurately reflect the scene.

Table. 1: Working face abutment pressure peak values table

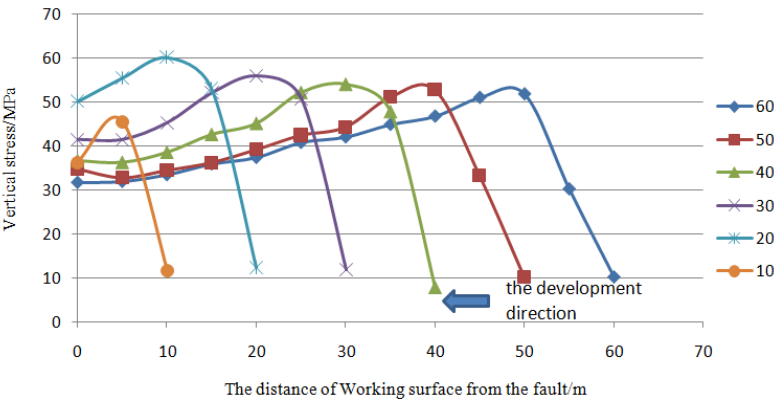| The distance from the fault /m	Abutment pressure peak value /MPa	The stress concentration factor
60	51.77	2.44
50	52.81	2.49
40	54.06	2.55
30	55.88	2.64
20	60.07	2.93
10	54.35	2.57
In-situ stress	21.17	1.00

Fig. 5: Working face front abutment pressure distributions (working face in the footwall)
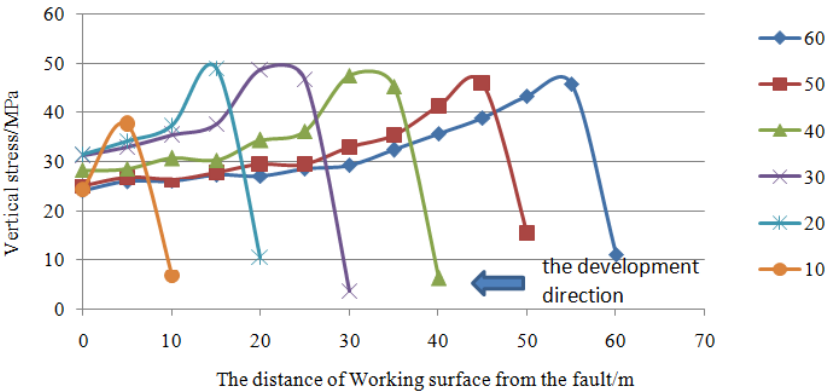

Fig. 6: Working face advance abutment pressure distribution (working face by the hanging wall)

When the distances between working face and fault are different during the working face is mined in the hanging wall of fault, these working face front abutment pressure distributions are shown in Fig. 6. As can be seen from Fig. 6, when the distances between working face and fault are 10，20，30，40，50，60 meters, the stress peak values stay the same all around 48MPa, less than the working face abutment pressure when the working face is mined in the footwall of fault.

2.3 The influence of fault dip angle on underground mining pressure

The above research proves that when the working face is 20 meters away from the fault plane , the influence of fault on the abutment pressure is strongest. Then the working face front abutment pressure distribution is simulated in the case of different fault dip angles when

the distance between working face and fault is 20 meters during the working face is mined in the hanging wall and footwall of fault. Basing on the above 30 ° initial model, the working face front abutment pressure distributions are simulated in the cases that fault dip angles are 15 °, 45 °, 60 °, 75 °, 90 ° respectively, the fault plane mechanical properties, strata physical mechanical properties and fault throw remain the same. Table 2 displays the front abutment pressure distributions under different fault dip angles when the working face is 20 meters away from the fault plane during the working face is mined in the hanging wall and footwall of fault. Fig. 8 is the time and space relationship curve of fault dip angles and abutment pressure peak values.

Table. 2: The table of working face front abutment pressure peak values under Different fault dip angles

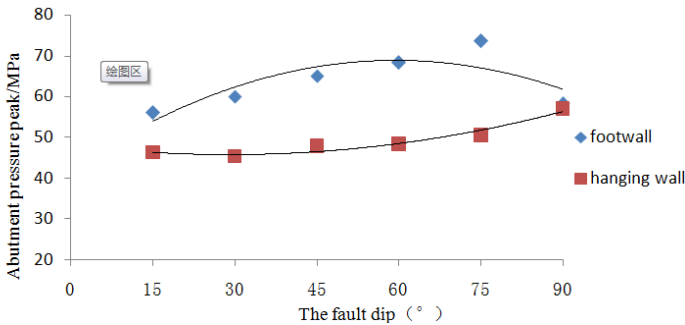| Co-hade /(°)	Peak stress /MPa	
	Working face located in the heaging wall	Working face located in the footwall
15	56.04	46.31
30	60.07	45.39
45	65.06	47.92
60	68.34	48.41
75	73.57	50.54
90	58.25	57.07

Fig. 8: Fault dip angles and the peak values of abutment pressure history

As can be seen from Fig. 8 and Table 2 that under the same fault dip angle, the working face front abutment pressure peak values during the working face is

mined in the footwall of fault all are bigger than in the hanging wall of fault. When the working face is mined in the footwall of fault, the working face front

abutment pressure peak values firstly increase with the increases of fault dip angles. When the fault dip angle is about 70 °, the front abutment pressure peak value reaches the maximum of 73.57 MPa. After that, the front abutment pressure values decrease with the increase of fault dip angles. When the working face is mined in the hanging wall of fault , the working face front abutment pressure peak values are roughly into a rising trend with the increases of fault dip angles.

Using the regression curve equation to analyze the data, we got that the relationship between coal front abutment pressure σ and fault dip angle θ is quadratic polynomial. The regression curve equation is as follows:

(1)when the working face is located in the footwall of fault

$$\sigma = -0.0059\theta^2 + 0.7223\theta + 45.08 \tag{1}$$

(2)when the working face is located in the hanging wall of fault

$$\sigma = 0.0023\theta^2 - 0.1006\theta + 46.477 \tag{2}$$

3. Conclusions

1）Thrust fault is more likely to induce rock burst than normal fault in the same geological conditions.

2）During the working face is mined in the hanging wall of fault, when the working face is 20 meters away from the fault plane, the influence of fault on the abutment pressure is strongest, where the abutment pressure peak value is 60 .07Mpa. During the working face is mined in the hanging wall of fault, when the distances between working face and fault are different, the working face front abutment pressure basically stay the same, where the peak values are all around 48Mpa.

3）When the working face is mined in the footwall of fault, the working face front abutment pressure peak values firstly increase with the increases of fault dip angles. When the fault dip angle is about 70 °, the front abutment pressure peak value reaches the maximum of 73.57 MPa. When the working face is mined in the hanging wall of fault, the working face front abutment pressure peak values are roughly into a rising trend with the increases of fault dip angles.

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