Study on Stress Distribution and Transfer Law of Simultaneous Mining in the Ultra-Close Thin Coal Seams

Kang jian, Sun guang-yi,Chen hai-bo, Yin xiao-jun

College of Resource and Environment Engineering, Heilongjiang Institute of Science and Technology, Harbin ,Heilongjiang, China
Email: kangjian94@126.com

Abstract: When ultra-close distance thin coal seams were simultaneously mined, causing the choice of coal mining method was more difficult because the analysis was not enough profound about the distribution of the abutment pressure and interaction mechanism. Using the FLAC^{3D} established numerical mechanics model, researched ultra-close distance thin coal seams with the simultaneous coal mining in the process change of the displacement field, the plastic area and the stress field, and exposed its stress distribution and transfer law, through the industrial-site tests, has been obtained the good technical economic effect. The result indicated that ultra-close distance thin coal seams with the simultaneous coal mining were solved by the method of establishment numerical mechanics model, compared the traditional method to be more effective and precise. It is worth further discussing and the application when ultra-close distance thin coal seams with the simultaneous coal mining were solved by numerical simulation.

Key words: ultra-close distance thin coal seams; upper and lower with the coal mining; stress distribution; transfer law

In the process of simultaneous mining of ultra-close distance thin coal seams, the stress redistribute because of the mine in upper seam. When the spacing of seams less than the damaged depth of floor, the spacing of seams reduced have more and more obviously influence on mining, specially the spacing small enough, interrelationship of simultaneous mining of ultra-close distance thin coal seams have direct influence on the choice[1-3] of mine layout and mining operation. In the process of simultaneous mining of ultra-close distance thin coal seams, study on stress distribution and Transfer Rule of simultaneous mining of ultra-close distance thin coal seams have important meaning[4-5] to find the mining method with technical, economy and safe. Numerical mechanics model was established by FLAC^{3D} in this paper, further study on stress distribution and transfer rule of the process of simultaneous mining of ultra-close distance thin coal seams by the change of displacement field, plastic zone and stress field [6-8].

1 Project Profile

Working seam in one coal mine belonged to the Chengzihe Jixi Group on the Jurassic coal-bearing; dip angle is 5° to 15° and developed stably. The upper thickness of 27# coal seam is 1.1m and the lower thickness is 1.2m in the coal mine, the band is composed of fine sandstone and shale, the thickness is 0.8 to 1.4m. By coal property assay, ash content in the upper 27# coal seam is 11%, calorific value ups to 29308KJ/Kg, average ash content in the lower is 24%,calorific value ups to 24280KJ/Kg, explosive index of coal dust is 37.91%, belongs to low-gas mine.

The original design of exploitation is regarded as two seams or one which have a band with simultaneous mining, then the total seam thickness is about 3.0 to 3.4m, mining is very difficult, more importance is that 30% to 40% of coal mixed with rock, take more difficult to washing coal for run-of-mine, at the same time, lost coal which on the top or floor layer will be throw away. take mining on every seam at the same time, arrangement preparatory workings and butt heading in every seams, top layer advanced than lower seam, the distance of top layer advanced than lower seam is based on equation $X_{\min} = H\cot\delta + L + b$, in the equation, H-distance of seams; δ - traveling angle of rock; L-safe distance, which is no less than 20 ~ 25m; b- maximum distance of face control of the upper seam, m. But it was found in the actual extraction process, the stress in lower seam's face control area is larger, difficulties in maintaining of face. Therefore, study on stress distribution and transfer rule of.

2 Numerical Simulation Analysis of Ultra-Close Distance Thin Coal Seams with Simultaneous Mining

2.1 Numerical Simulation

According interaction and feature of deformation in the process of simultaneous mining of ultra-close distance thin coal seams, study stress distribution and

978-1-935068-25-9

passing which belong to space problem, consequently, study on numerical modeling by FLAC^{3D} software.

Two seams spacing which are numerical modeling is 0.8m,1.1m the depth of upper seam is 1.1m,1.2m lower is 1.2m,average embedded depth of working face is 150m.

$$\sigma_z = \gamma H = 0.025 \times 150 = 3.75 \quad (\text{MPa})$$

For studying the interaction of top seam and lower seam which simultaneous mining. According to theory analysis, control the error caused by the calculation field that is permitted in engineering, the calculate model of $150\ m \times 120\ m \times 150\ m$ is large enough to meet the requirements. Surrounding rock divided in unit with the best way in layer, discrete divided by separating layer which parallels the bedding plane, divided the gratitude make the most of equality for assuring the require accuracy, as shown in Fig1.

Table 1 .Physical and mechanical property of surrounding rock

stratum	average thick -ness/m	property of rock	bulk modulus /GPa	shear modulus /GPa	cohesive /MPa	friction angle /（°）	density /kg/m^3
basic roof	8.2	fine-graind Sandstone	5.3	3.2	1.35	34	2600
immediate roof	1.6	slate	3.2	1.8	1.2	31	2500
27-1 seam	1.1	coal	1.4	0.9	0.5	28	1600
band	0.8	fine sandstone	5.3	3.2	1.35	34	2600
27-2 seam	1.2	coal	1.4	0.9	0.5	28	1600
immediate floor	5.8	fine-graind sandstone	5.3	3.2	1.35	34	2600

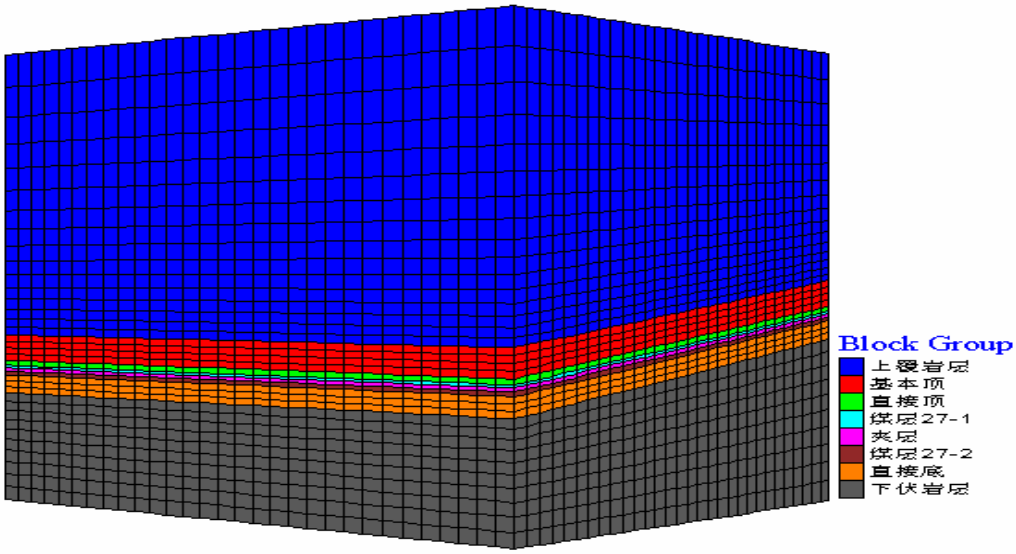

Fig1. Grid of computing mode

2.2 Process of Numerical Simulation

In view of characteristic of ultra-close distance thin coal seams, the coal seams were studied by simulation for weather simultaneous mining, so the advance distance of working faces are L＝30m、26m、22m、18m、14m、10m、6m in simulation. Make use of FLAC^{3D} that fast Lagrange with continuous medium to analysis Coulomb - Mohr criteria, the step is 4m.

2.3 Result of Numerical Modeling and Analysis

In this paper analyse the plan which had better effect of simulation and separation of simultaneous mining is 6m.

（1）Displacement Vector

（2）Plastic Zone

Interpretation of result of the eighth program：

（1）Distribution Characteristics of Displacement Field

With the working faces pushing, the maximum settle of roof is 22.1cm, the maximal swell of bottom is 2.5cm from z direction, and whole roof was falling.

（2）Distribution Characteristics of Plastic Zone

The degree of destroy is smaller than other program, from the plastic zone, along with advancing the unit of 8m on upper and lower working faces, some region were destroyed repeated and have not tensile failure, when the shear failure keep destroying the shed.

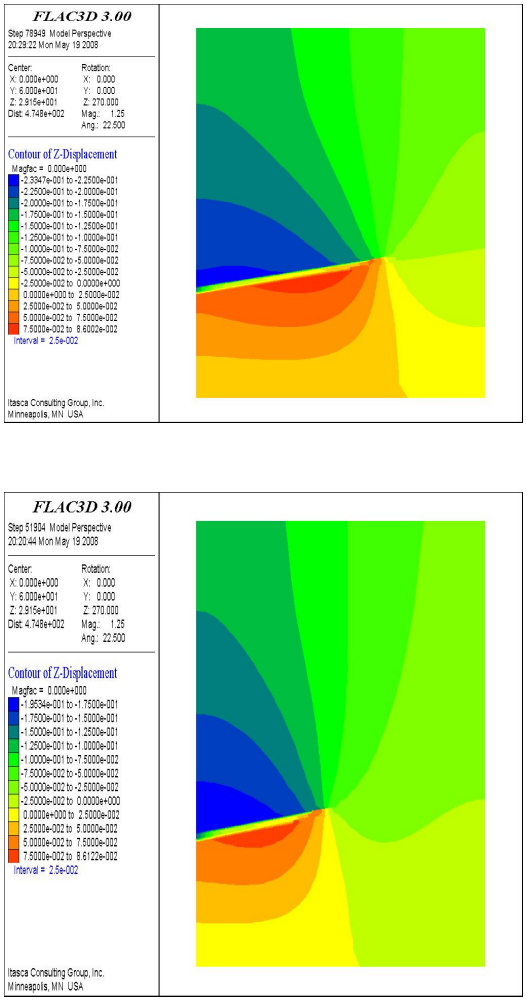

Fig 2. Displacement vector

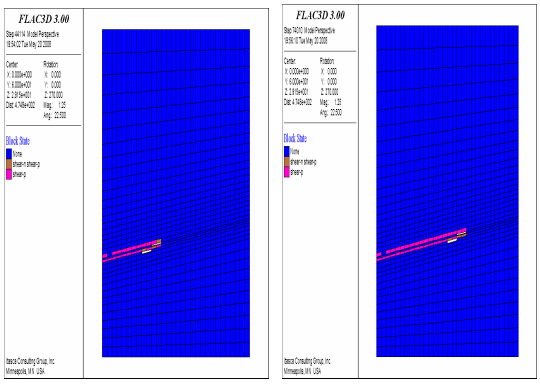

Fig 3. Plastic zone

（3）Maximum Principal Stress Distribution Chart

（4）Minimum Principal Stress Distribution Chart

（5）Abutment Pressure Distribution

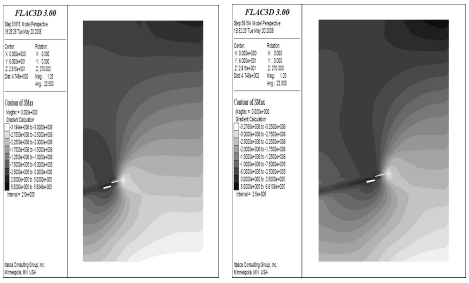

Fig 4. Maximum principal stress distribution chart

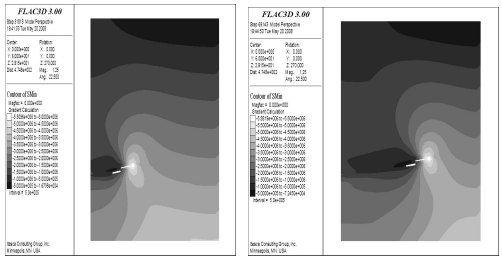

Fig 5. Minimum principal stress distribution chart

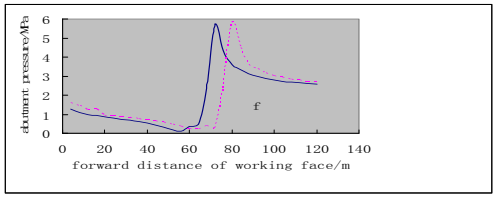

Fig 6. Abutment pressure distribution curve of mining face

（3）Distribution Characteristics of Stress Field

From maximum principal stress distribution chart, the value of stress is increasing trend, when the workplace advance ongoing, the maximum principal stress increased from 3.114MPa to 4.001MPa.

From minimum principal stress distribution chart, there were not tensile stresses when two working faces were simultaneous mining.

（4）Distribution Characteristics of Abutment Pressure

By advancing the working face, the internal stress steep rise before workplace about 4~8m, factor of stress concentration is 2.0, range of influence of high stress is 20m, the peak stress of upper face come up ahead of lower face.

Therefore, simulation and theoretical analysis by FLAC^{3D} in the process of simultaneous mining of ultra-close distance thin coal seams, put both of seams through stress wave, that is alternating effect of load and unload produced by fore and after bracing stress before mining. Simultaneous mining of ultra-close distance thin coal seams can be realized base on the rule and stress distribution in the process of simultaneous mining [9-11] of ultra-close distance thin coal seams.

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3 Industrial Field Test

（1）Technical Specifications

Test workplace is the first right workplace in 27# of fourth panel, long wall method in cross pitch mining by regular machine, altitude of mining is 0.8～1.2m, length of face is 104m, dip angle is 5°, the face are adopted MG80/200-BW double drum shearing machine with no haulage chain, SGZ-110 chain and flight conveyor, DZ-1.2 individual hydraulic prop with pole cap of home-made by iron, SGW-40T reversed loader and SJ-80 band conveyor in the haulage roadway.

（2）Working Face Roof Control

the roof Control by three or four columns that are DW08, DW10 individual hydraulic prop with pole cap of home-made by iron to expand the barring area and reduce the stress concentration on the upper workplace, circulation progress is 0.8m, array pitch is 0.6m, caving all of the roof in the gob.

Control the roof by three or four columns that are DW12, DW14 individual hydraulic prop with HDJB-800 headpiece and timbering by steel girder which length is 2.0m on the lower workplace, circulation progress is 0.8m, array pitch is 0.8m, length of column is 0.6m, all caving in of the roof in gob.

（3）Upper and Lower End Timbering

Using 4 beams and 8 column support the roof in upper and lower end accumulate wall of rock from gob to the second row of column in the lower end of the first. The last organ timbering at a range of 20m on upper and lower end controlled with double column.

（4）Advance Support

Adopt two row individual hydraulic prop and hinged bar timbering advanced 20m in the section of return airway, array pitch is 1.4m, column length is 1.2m; advance support 20m by two row individual hydraulic prop and I beam, array pitch is 0.8m, column length is 1.0m.

（5）Advance and Cut Way

Advance of tool with miter cutting the coal on the end in self-made breach.

（6）Mode of Operation

Three eight-hour shifts, mining with preparing, mode of operation on duty adopt sublevel integrated program. Chute moving delay winning machine 15m, no more than 30m; set column delay winning machine more than 15m, no more than 30m.

（7）Increase The Production Management

The distance didn't less than the rule which is separation between upper and lower workplace, avoid the dynamic impact influenced working of the lower seams. Don't make the rock of lower seam move at the same time, which will influence the face of upper seams.

4 Conclusions:

（1）The separation is different between seams when simultaneous mining of seams with very short interval, have inordinately influence for plastic zone, stress and changes in displacement of Coal mining rock, when the separation is adequate, the seams can be mine in the same time.

（2）Deformation and breakdown of shed produced in the process of simultaneous mining of seams with very short interval, was caused by alternating effect of load and unload produced by fore and after bracing stress before mining, degree of breakdown be linked with separation.

（3）Degree of breaking of the shed in simultaneous mining of seams with very short interval indicated by commercial test and observation of mining, simultaneous mining of seams with very short interval, and get distinct economic efficiency, therefore verify the correctness of theoretical analysis further.

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