Mine Water Inrush Prediction based on Virtual Large Diameter Well Method

Chen Shi 1,2 *

1 College of Water Resources and Architectural Engineering, Northwest A&F University, Yanglin, Shaanxi, 712100, China
2 Key Laboratory of Agricultural Soil and Water Engineering in Arid and Semiarid Areas, Ministry of Education, Northwest A & F University, Yanglin, 712100, China

*Corresponding author’s e-mail: aliphonse@gmail.com

Abstract. How to predict the mine water inrush is an important and complicated work. The virtual large diameter well method was widely used in mine water inrush prediction. This paper attempts to use the virtual large diameter well method to predict the amount of water inrush in the test area of the Taran Gale coal mine's first mine working face, and finally determine the amount of water in the mine.

1. Introduction

The coal seam of the Taran Gale coal mine is deeply buried. The water-conducting fracture zone formed by coal mining will not develop to the surface, so the atmospheric precipitation will not become the direct water-filling source of the mine.

There is no small coal kiln mining history around the mine. There is no old kiln distribution in the past. At present, there is no old air pollution in the mine. However, in recent years, with the large-scale development and construction of the Dongsheng coalfield, the production mines around the minefield (mainly in the eastern part of the minefield and the shallower depth of the coal seam in the north) are increasing year by year, and the area and water volume of the goaf are also increased. Increasing. Therefore, in the future, near the border of coal mining, it is necessary to pay close attention to the mining conditions of the surrounding mines, to prevent the hooking of adjacent goafs and prevent the occurrence of water inrush accidents.

The main aquifers in the mining area and the mine field include: Quaternary loose layer aquifer, Cretaceous subordinate Zhidan group (K1zh) fissure pore diving ~ confined water aquifer, Jurassic system - Jurassic middle and lower Tong Yan'an Formation (J2z~J1-2y) fractured pore confined water aquifer, Triassic upper extension group (T3y) fissure confined water aquifer.

The Quaternary loose layer aquifer will not directly fill the mine, and may become an indirect water-filled aquifer in the mine by replenishing the confined aquifer downwards, but the impact is minimal and may not be considered. The Cretaceous Tongzhi Dan Group (K1zh) fissure pore diving-contained water aquifer is nearly 300m away from the 3-1 coal seam and will not be affected by mining damage; there is a relatively stable Jurassic system top (J2a) partition. The water layer, the re-conservation porous pumping test has not found its existence with the 3-1 coal seam roof Jurassic Meso-Jurassic Middle Lower Yan'an Formation (J2z ~ J1-2y) fissure pore confined water aquifer exists in the hydraulic contact. Both the reconnaissance and previous exploration indicate that although there are some sandstone
aquifers below the 3-1 coal seam floor to the 5-1 coal seam floor, the overall water content is weak and there is no threat to mine safety. Therefore, the most influential to the mine water filling is the Jurassic Middle-Juraic Middle and Lower Yan'an Formation (J2z ~ J1-2y) fissure pore confined water aquifer, which is the aquifer section referred to in this report.

On the other hand, in the future mining of coal seams below 3-1 coal, it will be necessary to prevent the accumulation of water in the goaf formed by the upper 3-1 coal seam.

![Figure 1. Calculation range diagram.](image_url)

There are lots of factors contributing to mine water inrush, reasonable and effective plan to control water can be developed. [1]. The coal-bearing strata in the Taran Gale coal mine is the middle and lower Yan'an Formation of the Jurassic, and the main recoverable coal seam is 3-1 coal. In this calculation, the planned working face and test mining face in the two first mining areas are used as the calculation area for the initial mining water inflow. The calculation range is shown in Figure 1, and the area is 39km².

2. Virtual large diameter well method
The pressure-bearing to no pressure formula was used:

\[ Q = 1.366K \frac{(2H - M)M - h^2}{LgR_0 - Lgr_0} \]  

(1)

Since \( h = 0 \) when the mine is drained, the formula is changed to:
Q_{j}=1.366K \frac{(2H-M)M}{LgR_0 - Lgr_a} \tag{2}

Where Q are predicted mine water inflow; K are permeability coefficient (m/d); H are water column height (m); H_0 are the height of the remaining water column of the aquifer (m), h_0=H-S_{max}, when the aquifer is drained, H \approx S_{max}.

Therefore h_0 \approx 0; M are aquifer thickness (m); R_a are reference radius of influence, R_a=R+r_o(m); R are mine drainage impact radius (m), calculated according to empirical formula; R_0 are reference radius (m); F are The area of the mining area (m^2).

The hydrogeological parameters use this hydrogeological supplementary exploration results. Determination of the thickness A of the aquifer: the average thickness of the effective aquifer in the lower aquifer in the 13 boreholes. The height of the still water level H is the height (m) between the elevation of the average water level and the elevation of the floor of the aquifer.

3. Determining hydrogeological parameters

The hydrogeological parameters use this hydrogeological supplementary exploration results.

Determination of the thickness A of the aquifer: the average thickness of the effective aquifer in the lower aquifer in the 13 boreholes. The height of the still water level H is the height (m) between the elevation of the average water level and the elevation of the floor of the aquifer.

Affected radius R: When the mine is drained, the water level in the roadway system should be reduced to the aquifer floor, ie S=H, so the empirical formula is used:

R=2S \sqrt{HK} \tag{3}

Determination of the reference radius r_o:
When calculating the East and West Districts separately r_o=\eta(a+b)/4
Refer to the determination of the radius of influence R_0: R_0=R+r_0
The calculation parameters are shown in Table 1.

| Mining       | K(m/d) | H(m) | M(m) | R(m) | r_o (m) | R_0(m) | F(m^2)     |
|--------------|--------|------|------|------|---------|--------|------------|
| West         | 0.07835| 421  | 138  | 4831 | 2884    | 7715   | 23882939   |
| Eastern      | 0.07835| 421  | 138  | 4831 | 2380    | 7211   | 15256802   |
| Test         | 0.07835| 421  | 138  | 4831 | 367     | 5199   | 300000     |
| Mining       | 0.07835| 421  | 138  | 4831 | 3531    | 8362   | 39139741   |

Substituting the parameters of the above table into the calculation formula, the predicted mine water inflow is shown in Table 2.

| Mining range                  | Normal mine water     | Maximum mine water     |
|------------------------------|-----------------------|------------------------|
|                              | inrush (m^3/d)        | inflow (m^3/h)         |
| Separate mining              | 24318                 | 1013                   |
| Mining one east alone         | 21588                 | 899                    |
| Test face                    | 9031                  | 376                    |
| Mining two east and west mining areas at the same time | 27756                 | 1156                   |

| Mining range                  | Normal mine water     | Maximum mine water     |
|------------------------------|-----------------------|------------------------|
|                              | inrush (m^3/d)        | inflow (m^3/h)         |
| Separate mining              | 24318                 | 1013                   |
| Mining one east alone         | 21588                 | 899                    |
| Test face                    | 9031                  | 376                    |
| Mining two east and west mining areas at the same time | 27756                 | 1156                   |

Substituting the parameters of the above table into the calculation formula, the predicted mine water inflow is shown in Table 2.

Table 1. Inrush water calculation parameter list.

Table 2. Calculation result of water inrush under the condition that the aquifer is completely drained.
The normal water inflow predicted in Table 2 is the normal water inflow of the mine when the aquifer water level drops to the aquifer floor at the end of the first mining area and the first water level is calculated. The maximum water inflow is calculated as 1.2 times the normal water inflow.

4. Discussion on mine water inrush
Since the mining process is gradual, when the working face is mined one by one, the groundwater level falling funnel gradually expands as the goaf expands. In order to make the mine water inflow more realistic, according to the mine face mining plan, the test face will be mined in the first year, and then one working face will be mined at the same time each year in the Dongyi and Xiyipan areas, and the mining area will be directly filled with water. The layer is completely drained to the aquifer floor.

![Figure 2. Relationship between expected mine water inflow and mining time under complete dewatering conditions.](image)

In the early stage of mine mining, the amount of water inflow from the mine increases rapidly with the increase of the mining area. Then the slope of the water inflow curve decreases, and the amount of water inflow increases with the increase of the mining area. This is because the initial stage of mining needs to reduce the amount of water. Due to the static reserves of the layer. As the drainage time increases, the regional groundwater level decreases. In the long run, the actual water inflow in the mine should be less than the expected water inflow. It is not difficult to see that the expected change of mine water inflow is in line with the change law of mine water inflow.

5. Conclusion
In fact, even if the mining section is completely mined, the directly water-filled aquifer on it will not be completely drained, but there will still be a certain head height (the Shendong mining area has conducted many actual observations, which confirms this). a little. Therefore, the amount of water in the mine that is expected to be completely drained by the aquifer is often too large. In order to make the expected result of water inflow more close to the actual situation of future mining, the water inflow of the mine is predicted again by draining 85% of the thickness of the directly filled aquifer.

Acknowledgments
This research was supported by projects from national natural science foundation of China (NO.41602254), and Special Funding Project for Basic Scientific Research Business Fees of Central Universities (2452016179), Double-class discipline group dry area hydrology and water resources regulation research funding project (Z102021853).
References

[1] AE Roemershauser, MF Hawkins Jr. The Effect of Slant Hole Drainhole and Lateral Hole Drilling on Well Productivity [J]. Journal of Petroleum Technology., 1955, 7, 11–14.

[2] CHANG, M.M.: “Simulation of production from wells with horizontal/slanted laterals. Final Report”, [C]. DOE Reporter NIPER-326, March 1989.

[3] Cooper, H.H. and C.E. Jacob. A generalized graphical method for evaluating formation constants and summarizing well field history[J]. Am. Geophys. Union Trans., 1946. vol. 27, pp. 526-534.

[4] Besson, J. Performance of slanted and horizontal wells on an anisotropic medium [C]. European Petroleum Conference, 21-24 October, The Hague, Netherlands SPE 20965, 1990.

[5] Morita, N., Singh, S.P., Chen, H.S., Whitfill, D.L., Conoco Inc. Three-Dimensional Well Model Pre-Processors for Reservoir Simulation With Horizontal and Curved Inclined Wells[C]. SPE 20718, 1990.

[6] Casasent D, Wang Y C. “A hierarchical classifier using new support vector machines for automatic target recognition.” Neural Networks, vol. 18, pp.541-548, May 2005.

[7] Yang Yongguo, Huang Fuchen, “Water source determination of mine inflow based on nonlinear method,” Journal of China University of Mining and Technology (Natural Science), vol. 36, pp. 283–286, March 2007.

[8] Hao P Y, Chiang J H, Tu Y K, “Hierarchically SVM classification based on support vector clustering method and its application to document categorization” Expert Systems with Applications, vol. 33, PP. 627–635, March 2007.

[9] J. Annan, L. Bing, “Particle swarm optimization support vectors machine method of identifying standard components of ions of groundwater,” Journal of China Coal Society, vol. 31, pp. 310–313, March 2006.

[10] T. Lian-sheng, W. Si-jing, “Progress in the study on mechanical effect of the chemical action of water-rock on deformation and failure of rocks,” Advance in Earth Sciences. vol. 14, pp. 433–439, May 1999.

[11] L. Ning, Z. Yun-ming, S. Bo, et al, “A chemical damage model of sandstone in acid solution,” International Journal of Rock Mechanics and Mining Sciences, vol. 40, pp. 243–249, May 2003.

[12] Mochizuki S. Inflow Performance Relationships for Solution-GasDrive slanted Horizontal Wells[C]. SPE 20720, 1990.