Research on the Influence of the Kilometers Rig Drilling Parameter on the Gas Drainage Effect

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Abstract: In 2005, VLD kilometer rigs were applied in Sihe Mine of JinCheng Anthracite Mining Group, but because of borehole equipment factors, drilling technology, mainly coal geological conditions, lead to poor drilling results. According to the situation of Sihe Mine, we can do experiments of drilling rig kilometers on typical coal, after analyzing and researching relationship with gas resoluble and experimental drilling which includes drainage negative pressure that is between 8kPa and 20kPa and drilling length that is among 400m, 600m and 800m. Finally we can get the effective parameters of kilometer drilling. Get conclusions: At the same drilling depth, the changing of negative pressure has little effect on gas flow, the negative pressure of drainage is adopted between 15 and 20kPa in Sihe Mine. Gas drainage concentration, extraction negative pressure and extraction flow are closely connected, if one factor’s change will lead to other factor’s change. So in order to get the best drainage conditions we must monitor and control them; With the increasing depth of drilling the initial drilling gas flow also increases, however, the increase of initial gas flow is not proportional to the depth of drilling, in the same conditions, the drilling depth influences gas drainage quantity, the longer the length of drilling is, the larger amount of gas drainage is. Comprehensive consideration, 600m is advisable for Sihe Mine kilometer drilling.

Keywords: the kilometers rig drilling; long holes; negative pressure; gas drainage concentration; depth of drilling; attenuation coefficient

1 Introduction

The effect of drilling gas drainage is mainly affected by the air permeability of coal in extraction area, the use of 1000 m long drilling rig can destroy the coal structure, form a certain range of coal unloading pressure, increase coal seam permeability in the region and then improve the effect of drill drainage. The effect of drill gas drainage is affected by extraction technologies, so the effect of drilling parameters (extraction negative pressure, drilling depth) and the effect level of these factors which impact on gas drainage should be investigated and realized. In this paper, through inspecting the effect of Sihe Coal Mine’s 1000m length-drill hole on gas drainage and analyzing the influencing rule between the gas drainage effect and drill parameters, then the impact of extraction negative pressure and the length of drilling are got, and finally the effective extraction negative pressure and reasonable drilling length of Sihe mine are determined.

2 Theoretical analysis of gas drainage in coal seams

2.1 The calculation of gas drainage (Lin, 1998), (Ma, 2007)

On the basis of radial gas flow theory, when the flow time is very long (F₀ = 10³ ~ 10⁷), the gas flow is stable; under this circumstance we can analyze every parameter’s influence on the amount of gas drainage. When the flow time F₀ is between 10³ and 10⁵,

\[ Y = 0.512 F₀^{0.10} \]  (1)

Where \( Y = q R_t \lambda (p_0^2 - p_t^2) \); \( F₀ = 4 \lambda R_t^2 \eta / \rho_1 \) \( p_1 = 0.1 \text{MPa} \)

The computing formula of total gas flow as follows:

\[
\begin{align*}
Q &= 2\pi R_t m q \\
q &= 0.502^{0.09} p_0^{1.85} R_t^{-0.8}\eta^{0.1} l^{-0.1} \\
Q &= 3.14 m\lambda^{0.9} p_0^{1.85} R_t^{-0.2}\eta^{0.1} l^{-0.1}
\end{align*}
\]  (2)

From the above formula of the total gas flow, in the steady flow state after a long drainage time the total gas flow \( Q \) is proportional to the coaled thickness \( m \),
and is proportional to gas pressure $p_0$ to the 1.85th power, to permeability coefficient $\lambda$ to 0.9th power, to drilling radius $R_1$ which has little effect 0.2th power. So the key parameters of gas flow are the permeability coefficient $\lambda$ and gas pressure $p_0$. But the original gas pressure of coal seams can not be changed, at present in China the original gas pressure is generally less in 4MPa, only very few reach to 10MPa or more. Therefore, the key to improving the amount of gas drainage is how to improve the gas permeability coefficient $\lambda$.

### 2.2 Gas drainage form kilometer length-drill hole

We have known that the key to improving the amount of gas drainage is how to improve the gas permeability coefficient $\lambda$. And nowadays how to improve seam permeability is a worldwide problem. Faced with this problem, the research and development of gas drainage technology, the manufacture of drilling tools and the study on construction technology have become the new research field which can improve coal seam permeability. The spread and exploitation of using 1000m drilling machine is a perfect addition to the gas drainage.

In the United States and Australia, 1000 m drilling machine has been widely used in gas drainage, the longest drill can reach record 1500m (Jing, 2003). The 1000 m drilling machine use directional drilling technology, achieve directional drilling, which can make sure drilling reach the specified position, and can guarantee to achieve uniformity holes arrangement in coal seams, dispel the phenomenon of drill perforation, then ensure drainage effect; in the construction of drilling hole when meeting the ground conditions, in order to reach the design depth we can use 1000 m drilling machine to drill branch, and 1000 m drilling machine almost has no waste drilling hole, also has efficient drilling rate, can improve the gas drainage results; Drilling technology can cut across coal texture, parting and damage the coal seam structure, finally increase the gas drainage effect; besides, 1000 m drilling machine can verify geological structure, increase comprehensive coverage of drilling hole on the coal seam, reduce the blind spot of gas drainage which reduce the drilling engineering quantity (He, 2009), (Li, 2009).

### 3 Negative pressure’s influence on gas drainage

In gas drainage, extraction boreholes have certain negative pressure which can guide gas to the gas drainage pipes, the pressure gradient between extraction negative pressure and coal vacuum gap can speed up the velocity of gas adsorption (Lin, 1998). Determining a reasonable gas drainage negative pressure has a significant role on increasing the effect of gas drainage.

On the basis of Sihe Mine we research and analysis the gas drainage parameters’ relation with negative pressure, these parameters mainly include concentration, gas drainage mixed quantity and gas drainage of pure volume from XiaoDongshan and XiGui working face's long holes. And then draw the relation between negative pressure and gas drainage parameters, these curves are shown in Figure 1 to Figure 6.

![Fig.1 The relation between gas drainage parameters and negative pressure of the 2nd bore hole in XiaoDongshan](image-url)
Fig. 2 The relation between gas drainage parameters and negative pressure of the fourth bore hole in XiaoDongshan

Fig. 3 The relation between gas drainage parameters and negative pressure of the sixth bore hole in XiaoDongshan

Fig. 4 The relation between concentration and negative pressure of the seventh bore hole in XiaoDongshan
Gas drainage concentration reflects the ratio of gas in the mixed-flow which accounts for total gas drainage, also reflects the sealing of drainage pipe and drilling, if the mixed flow is great while the gas drainage concentration is small, it shows that the pipe may be not airtight, there must be a large number of air goes into the drainage pipe form outside; in contrast the great gas drainage concentration reflects the good seal of pipe.

According to the analysis of these curves as above, we get conclusions:

(1) Along with the conduct of extraction, the volume of gas drainage decreases, the gas drainage negative pressure increases, and then the volume of gas drainage has an increment, on the contrary the gas drainage negative pressure decrease.

(2) Form a certain drilling depth, the changes of negative pressure has little effect on gas flow;

(3) For the 1000 m drilling machine, enough negative pressure is generally helpful for gas drainage, because of its initial flow is very great; In Sihe Mine the negative pressure should be 15 ~ 20kPa.

(4) There are some influences of one on the other among gas drainage concentration, gas drainage flow and the negative pressure; any change will cause other change. In the drainage management, we should monitor the three parameters, and then according to the actual situation we control them, and ensure better extraction results.

4 Drilling depth’s effect on gas drainage

In gas drainage, the gas flow is the accumulation of gas emission form exposed holes on wall, the longer the length of drilling, the greater the amount of gas drainage in per unit time; increasing the depth of
drilling in coal seams has a significant effect to improving the drainage capacity of the gas drilling, and the amount of gas drainage gradually increases with the increased depth of drilling. Because of the increased drilling depth, the drilling wall has more exposed area from which a lot of gas flow into gas drill, then the gas drainage volume of single-hole becomes greater. However, the length of the drilling is also affected by geological conditions factors, through the research and analysis on the influence of different length in Sihe Mine’s kilometers length-drill on the gas drainage, an optimal depth was proposed for Sihe Mine.

4.1 The influence of drilling length on the volume of gas drainage

Under the same diameter of 113mm bore, we analyzed the influence of kilometers length-drill under three different lengths of 800m, 600m and 423m on gas drainage, and then draw the relation between gas flow and time. these curves are shown in Figure 9 to Figure 11.

From the above charts we know that the initial gas flow per 100m of 800m drilling is 1.4754m³/min.hm; the initial gas flow per 100m of 600m drilling is 1.3195 m³/(min. hm); the initial gas flow per 100m of 423m drilling is 0.2166m³/min.hm. Along with the growth of the extraction time, the gas flow changes in different attenuation which is under the influence of different attenuation coefficient.

The comparison among three gas drainage under different length is showed in Table 1

From the table we obtain that the ratio of 423m,
600m and 800m length is 1:1.42:1.89, the ratio of initial gas flow is 1:6:6.71. Through the analysis of the Qct = 0.2141e^{-0.0044t}

![Fig.9 The relation between gas quantity and time in a borehole of 423m in depth](image)

<table>
<thead>
<tr>
<th>drilling length /m</th>
<th>drilling length /per 100m</th>
<th>initial gas flow /m³ (min·hm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>423</td>
<td>4.23</td>
<td>0.22</td>
</tr>
<tr>
<td>600</td>
<td>6</td>
<td>1.32</td>
</tr>
<tr>
<td>800</td>
<td>8</td>
<td>1.48</td>
</tr>
</tbody>
</table>

Each unitage all convert into per 100m

three types drilling’s impact on gas drainage, we know that along with the increasing of drilling length the initial gas flow also increase, and the attenuation coefficient decreases, which is good to gas drainage.

4.2 The influence of drilling length on total amount of gas drainage

The relational graph between the gas drainage total content of total kilometer length-drill hole and gas drainage time is showed in Figure 10.

From the chart we get that under the same gas drainage time, it shows that the total volume of gas drainage of 800m drilling is biggest, next is the 600m drilling and the 423m drilling is smallest., the greater the length difference between these drilling, the greater the cumulative gas drainage volume will be.

Results: The length of the drilling impact on gas drainage volume, under the same conditions, the longer the gas drainage drilling, the greater the cumulative gas drainage volume. In the actual process of gas drainage, the length of drilling is limited by rig drilling ability, the longer the length of drilling the greater difficult the boring construction. As the current construction of drilling in Sihe Mine we think that
600m is the reasonable and effective construction length.

5 Conclusion

According to the research and analysis on the influence of drilling parameters (including the length of drilling and gas drainage negative pressure) on the gas drainage, we get the following conclusions:

(1) On the constant drilling depth, the changing of negative pressure has little effect on gas flow; negative pressure drainage is adopted between 15 and 20kPa in Sihe Mine. (2) Gas drainage concentration, extraction negative pressure and extraction flow are closely connected, if one of them changes will lead to others’. So in order to get the best extraction conditions we must monitor and control them; (3) With the increasing length of drilling the initial drilling gas flow also increases, however, the increase of initial gas flow is not proportional to the length of drilling, in the same conditions, the drilling length influence gas drainage quantity, the longer the length of drilling is the larger amount of gas drainage is, Comprehensive consideration, 600m is advisable for Sihe Mine kilometer drilling.

References