Some solutions for handling and mining the spontaneous combustion coal seams of underground coal mines in Quangninh coal area, Vietnam

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Abstract:
The phenomenon of spontaneous combustion coal in some underground coal mines of Quangninh coal area was really detected in about five years ago. The miners at the workplaces in underground mining as longwall mining, room-and-pillar mining, has been poised by carbon monoxide, the environmental temperature increased high (to 50° C) with the smoke caused coal fire. The safety and health of miners were threatened, some underground coal mines has been enforced to close temporary to waiting for relevant solutions of handling and mining.

The spontaneous fire of most coal seams in some mines of Quangning coal area have been mining by longwall with inclined seam (angle of dip < 35°), full caving by drilling-blasting of thick coal seam matching (about 2.2 m) or excavated floor sloping slice and retrieved roof sloping slice. Some coal seams are thicker than 3 m and steeper than 35° have been mining by horizontal slices or diagonal slices method. The roof controls in the workplace are friction props and hydraulic props. After the coal has been extracted, the roof of the void in left behind the face was itself collapsed. The los coal during the collapsed roof in the gob was main cause of spontaneous fire in underground mining in Quangninh.

The technical solutions in order to handle and mine the spontaneous fire coal area were applied as water spray, building wall to seal of the fire area and the monitoring of fire area has been implemented.

Some renovated technologies of underground mining in Quangninh can be applied to excavate the spontaneous combustion coal seams have been researching. The report is presented some solutions of handling and mining the spontaneous fire of coal during the excavation by underground mining in Quangninh coal area and some renovated mining method are summarized simultaneous in this report.

Keywords: QuangNinh coal area; anthracite in Vietnam; spontaneous combustion coal in QuangNinh;

1 Introduction
Quangninh coal area of Vietnam has been recognized and exploited since at least 150 years ago. The surface coal mining process in Quangninh hasn’t been observed the phenomenon of spontaneous combustion coal. But during the underground coal

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mining in Quangninh has been happening fires and gas explosions. Table 1 show some typical incidents which noted in Quangninh coal area.

**Table 1: Some typical incidents due to the fires and gas explosion in underground coal mines of Quangninh coal area [1, 2, 3]**

<table>
<thead>
<tr>
<th>No.</th>
<th>Local</th>
<th>Year</th>
<th>Cause</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Fire in Halam mine</td>
<td>1975, 1985 and 1990</td>
<td>Fire from miners</td>
<td>No death</td>
</tr>
<tr>
<td>02</td>
<td>Fire in Vangdan mine</td>
<td>1985</td>
<td>Fire from miners</td>
<td>No death</td>
</tr>
<tr>
<td>04</td>
<td>Fire in Thongnha mine</td>
<td>1978</td>
<td>Fire from miners</td>
<td>No death</td>
</tr>
<tr>
<td>07</td>
<td>Concealed fire of seam No. 24 of Hongthai mine</td>
<td>2004</td>
<td>Self-heating of coal</td>
<td>No death</td>
</tr>
<tr>
<td>08</td>
<td>Concealed fire of seam No. 5, Khechuoi mine</td>
<td>2005</td>
<td>Self-heating of coal</td>
<td>No death</td>
</tr>
<tr>
<td>09</td>
<td>Gas explosion in Maokhe mine</td>
<td>1999</td>
<td>Cigarette smoking</td>
<td>24 deaths</td>
</tr>
<tr>
<td>10</td>
<td>Gas explosion in Thongnhat mine</td>
<td>2006</td>
<td>electric</td>
<td>8 deaths</td>
</tr>
<tr>
<td>08</td>
<td>Gas explosion in Khecham mine</td>
<td>2008</td>
<td>Fire from miners</td>
<td>10 deaths</td>
</tr>
</tbody>
</table>

The fire incidents due to the mistake of miners in some underground mines were extinguished by pumped flooding of seawater, e.g. in Halam- and Thongnhat mine. After the fire was extinguished the underground mining was recovered with a lot of difficulties and loss.

In Vietnam the phenomenon of self-heating of coal was recognized in some small mines, e.g. Nduong (Langson province), Khebo (Nghean province), Langcam and Phanme (Thainguyen province).

The spontaneous combustion coal has been recognizing since 2004 in Hongthai- and Khechuoi mine of Quangning coal area. The researches of event show that, the spontaneous combustion coal seams in Hongthai and Khechuoi are semi-anthracite. The spontaneous heating of these coal seams to concealed fire is from 31 to 42 days and the self-heating temperature reached to 90°C [2].

2 The phenomenon of spontaneous combustion during the underground coal mining in Quangninh.

2.1 The concealed fire at coal seam No. 5 of Khechuoi mine

The coal seam No. 5 of Khechuoi mine has average angle of dip in 30° and the thickness is 2 m. The seam has been mining by longwall method in the level from +370 to +413, the full caving by drilling-blasting. The ventilation of mine is an exhaust fan that located at the portal +413. The exhaust fan has a capacity in 11 KW,
the maximum air flow is $4 \text{m}^3/\text{s}$ and maximum pressure is 235 mmH$_2$O. Figure 1 shows location of seam No. 5 of Khechuoi mine and its ventilation system.

Figure 1: Outline of ventilation system for coal seam No. 5 of Khechuoi mine (not scale)

In February 2007 the monitoring results of gas at the longwall of seam No. 5 show the carbon monoxide concentration exceeded threshold limited value and the workers in underground mining have feel headache.

Because the longwall of seam No.5 was suspected the phenomenon of spontaneous combustion, then it has been stopped since February 2007 to wait for solutions in order to handle and extract continuously.

2.2 **The concealed fire at the seam 24 of Hongthai mine**

The seam No. 24 of Hongthai mine has been operating since 2003. The seam has average angle of dip in 35° and the thickness is 2.2 m. Longwall is used to extract the seam. The method of roof control is full caving and support in longwall by using wooden and hydraulic props. The transport of coal in longwall is rail-free system [..].

The spontaneous combustion of coal seam No. 24 of Hongthai mine has been recognized in May 2004. Its phenomenon was smoke, the carbon monoxide concentration increased to exceeded threshold limited value. The workers in longwall have feel headache and the temperature was measured higher 40° C in longwall. The mine has handled temporary by sealing fire area.

3 **Extinguishing fire and Precaution against the spontaneous combustion**

After the phenomenon of spontaneous combustion are recognized in Quangninh coal area, the VINACOMIN cooperated with university to study the potential spontaneous combustion coal in some underground coal mines of Quangninh. The study results confirmed the spontaneous combustion of the coal seam No. 5 of Khechuoi mine and coal seam No. 24 of Hongthai mine. The measures to handle and mine those coalseams have been taken in this study simultaneously.
3.1 Solution for longwall face of coal seam No.24 of Hongthai mine

After the concealed fire is recognized at the coal seam No.24 of Hongthai mine, the temporary solutions to extinguish fire are used as following [2]:

- Technical solution for handling first times: Water was pumped down to fire area in the longwall of coal seam No.24. The temperature of wastewater from fire area measured in 48° C. The carbon monoxide concentration has exceeded 0.0017%. These results shown the extinguishing effect by water pumping was the requirement without satisfying. Then this solution was stopped to wait for a new measure.

- Technical solution for handling second times: The detecting of spontaneous heating at the fire area was made by monitoring gas concentration in return airways. It is shown the increasing strength of carbon monoxide concentration. So, the stopping method was followed by the building a wall with the sandbags materials. The monitoring of gas concentration beside the stopping wall shown the carbon monoxide concentration was under threshold limited value. Then Hongthai mine has developed a new extraction face with level from +200 to +320. But in August 2004 that longwall has released the smoke.

- Technical solution for handling third times: After detection the smoke at the return of airflow in level +320, the fire area was determinate and stopped in level from +280 to +320. The fire area was monitored the gas concentration. The face had been extracting in level from +200 to +280. But in May 2005 the measured carbon monoxide concentration at this face was exceed threshold limited value.

- Technical solution for handling fourth times: In May 2005, after the spontaneous combustion was detected, the stopping solution had been using. A single walled structure constructed from sandbags. The monitoring system of gas concentration signs the existing of considerable carbon monoxide beside the stopping wall.

Though the Hongthai mine had used those solutions to extinguish the fire area, but the concealed fire of coal seam was still continuous. Their causes were the supply the oxygen from intake and return of airflow into the caving area of longwall wasn’t full sealed off.

Due to the technical solutions for handling of the concealed fire at the longwall of coal seam No.24 of Hongthai mine had the without effect as mines wish. The semi-backfill method for caved area had been using. The haulage road and returned airway were sealed to take precaution against air leakage path between intake and return. Figure 2 represents the diagram of this measure.
The longwall face before semi-backfill

The longwall face after semi-backfill

Figure 2:
The gas monitoring should be to follow three shifts a day. Another legal for safety of fire and gas explosion in underground coal mining must be enforced. The gas monitoring included additional legal as following:

- Gas concentration had been measuring two hours / time at the positions along longwall both face and gob area. The distance between the measured positions is 10 m. If the carbon monoxide has been identified increasing, then the miners must be stopped all of works at the longwall face and emergency to go to safety positions.

- The workers at the longwall face must be equipped a signal automatic to identify gas concentration.
The mine director must management to extinguish and handle the spontaneous combustion coal seam. The mine director has mission to report the present condition of coal seam fire with the leadership of VINACOMIN.

The use of semi-backfill methods had experimented and reached effect to meet full. Longwall face in level from +200 to +280 had been mined with sum 91,259 metric tons coal. In level from +190 to +240 mined with sum 5,400 metric tons and from +126 to +190 had been mined 311,626 metric tons coal. During the mining hadn’t got any happened breakdown.

3.2 Solution for concealed fire area of coal seam No.5 of Khechuoi mine

After the spontaneous combustion of coal seam No.5 was indentified and the concealed fire area was determinate. The stopping measure was implemented by double walls. The thickness of internal wall is 5 m and constructed by the sandbags with the clay infill to minimize air leakage from gob area. The followed wall was built by the brick. Two tubes are set up for gas sampling and water drainage from sealed area. The gas from sealed area is drainage to portal by pipeline system. Figure 3 illustrates the construction of double walls.

![Figure 3: Illustration of the stopping construction against concealed fire area belong seam No.5 of Khechuoi mine](image)

Simultaneously, the surface over of caving area is sealed in order to fill up the cracks and faults due to the subsidence and geological structure.

The monitoring system of released gas concentration from sealed area was enforced in a very strict manner. In June 2008, the measured carbon monoxide concentration was under the threshold limited value.
Since June 2008, the sealed area was reopened and an air circuit was re-established suddenly. The gas monitoring and control system still maintain and nowadays the coal seam No.5 of Khechuoi has been mining.

4 Discussion and Conclusion

The experimental researches to mine at the concealed coal seam in Quangninh indicated the challenge and difficult of Vietnam on the extinguish fire and precautions against spontaneous combustion coal seams.

The solutions for handling and mining of concealed fire at the active coal seams are described as over sections which are only oldest and most methods. The study in the fields of spontaneous combustion coal seams is a new for Vietnamese researchers. Vietnam hasn’t got enough experimental labors for those studies.

Up to now the preliminary research for concealed fire of coal seams in Vietnam has shown the considerable resources of the spontaneous combustion coal. Since 2009 the institute for mining science and technology of VINACOMIN has been studying to innovate the technical underground mining for spontaneous combustion coal seams in Quangninh. Simultaneously, the labor for study of self-heating of coal seam has been building by VINACOMIN [...].

References


[13]