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IDENTIFICATION OF SPONTANEOUS COMBUSTION PRONE ZONES IN LONGWALL TOP COAL CAVING GOAFS

Jun Xie^{1, 2}, Sheng Xue² and Weimin Cheng¹

ABSTRACT: Longwall top coal caving (LTCC) mining method has been used to extract thick coal seams in China. Unfortunately the method has also brought with it an increased risk of spontaneous combustion (sponcom) in active LTCC goafs. It is therefore critical to identify the sponcom prone zones in LTCC goafs so that remedy measures can be taken to prevent sponcom from occurring. One of the successful methods to identify the sponcom prone zones is through the combination of field measurements of temperatures and oxygen concentrations inside a LTCC goaf and numerical modeling. A new technique has been developed specifically to enable the field measurements inside LTCC goafs to be easily undertaken. Presented in this paper are the description of such technique and its successful application in Xinglongzhuang coal mine of Yankuang Group, China.

INTRODUCTION

The LTCC system of mining thick coal seams is a productive and cost effective method, which has been widely used to extract thick coal seams in China. However the application of the method has also brought with it an increased risk of sponcom in active LTCC goafs because of the large caving zones formed and some fragmented coal left in the goaf. It is therefore critical to identify the sponcom prone zones in LTCC goafs so that measures can be taken to prevent sponcom from occurring.

Due to the inaccessible and complex nature of LTCC goafs, it is very difficult to make direct measurements inside the goaf although a number of attempts have been made with limited success (Luo, 1998; Xu, 2001; Wang *et al.*, 2005). A new technique has been successfully developed to measure insitu temperature and oxygen concentration inside LTCC goafs. This paper describes the technique and its application.

FIELD TESTS AND RESULTS

Test Site

A field test was undertaken in #4326 LTCC face of Xinglongzhuang coal mine of Yankuang Group, China. The #3 coal seam is mined with an average thickness of 8.6 m (mining height is 3 m and caving height is 5.6 m) and the seam dips at 6°. The panel length is 1410 m and the face is 300 m wide. The overburden depth ranges from 470 m to 517 m. The seam is prone to sponcom with an incubation period of 3-6 months (the shortest incubation period is only 22 days). The face is "U" type ventilated with an air flow of 20 m³/s. A schematic of the panel layout is shown in Figure 1.

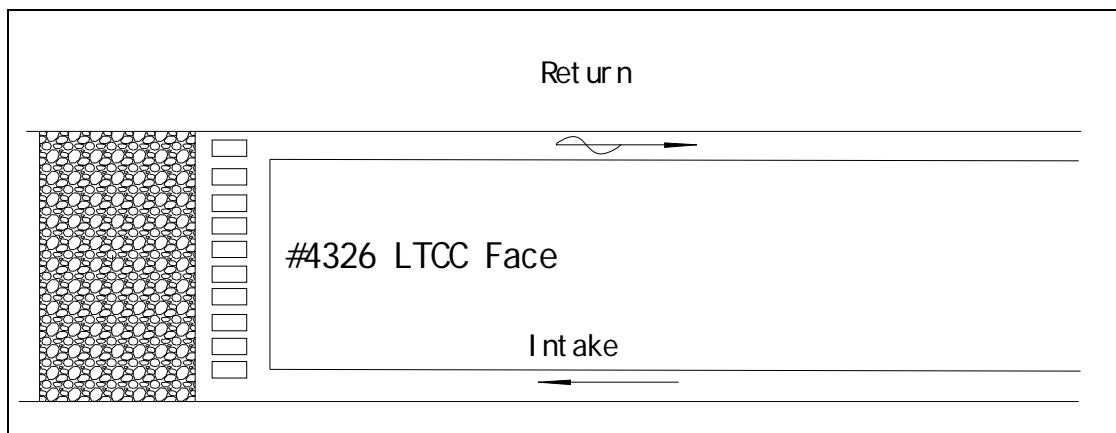


Figure 1 - Layout of #4326 LTCC face, Xinglongzhuang mine

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Test Technique

A total of 7 measurement points were placed behind the rear AFC along the face using a 50m spacing and numbered as #1, #2, #3, #4, #5, #6 and #7 respectively (Figure 2).

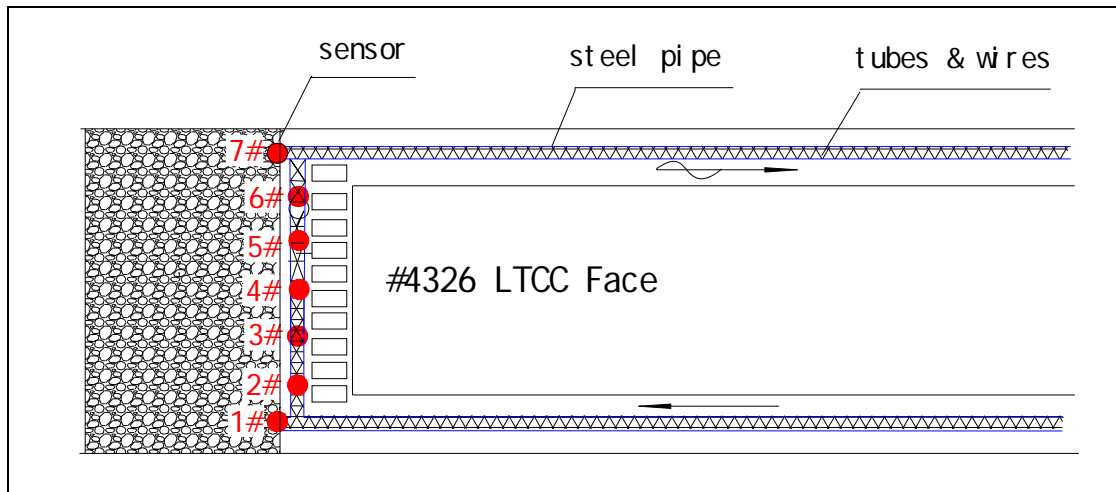


Figure 2 - Layout of measurement points at #4326 LTCC face

At each measurement point, a temperature sensor and gas sampling tube were installed, and the sensor and tube were contained inside a perforated short steel pipe. A quick connector is fitted in the pipe for a signal transfer wire and the tube to be connected with a connector in a long steel pipe installed along the face (Figure 3). This enables the continuous and simultaneous temperature measurements and gas sampling at the 7 measurement points. As the face retreats, the perforated steel pipes containing sensors and tubes are buried inside the goaf, and the temperature and gas concentration inside the goaf are then measured.

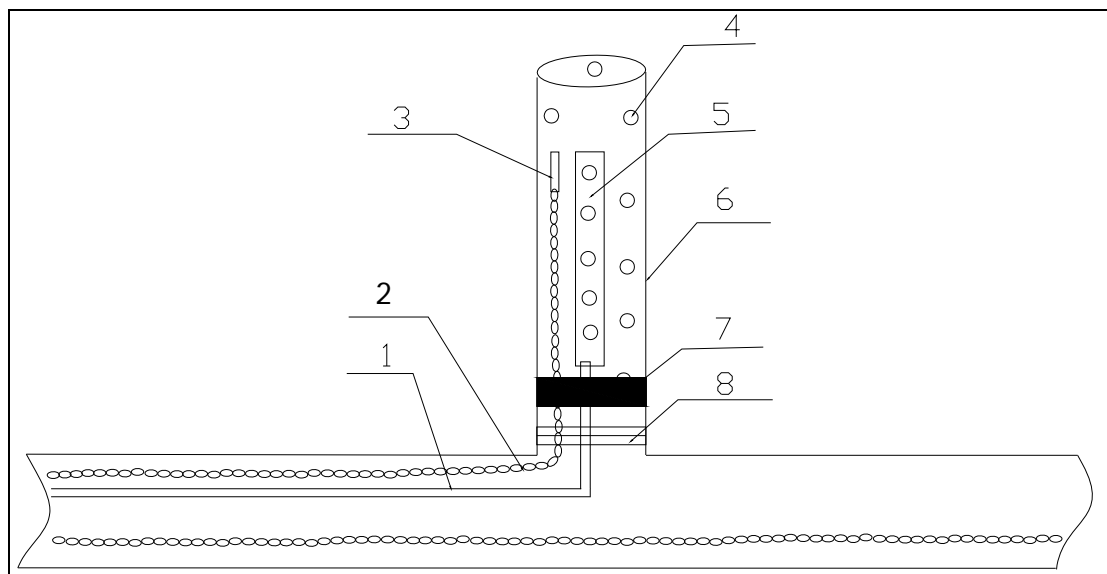


Figure 3 - Schematic of a measurement point

1 tube; 2 temperature wire; 3 temperature sensor; 4 opening in steel pipe;
5 dust filter; 6 steel pipe; 7 sealing material; 8 quick connector

Test Results and Discussions

The field test lasted for 30 days while the face retreated over 240 m. Test results are shown in Table 1. The results were then analysed in terms of the variation of temperature and oxygen concentration with the face retreat and are shown in Figures 4 and 5.

Figure 4 reveals that the temperature inside the goaf increases with face retreat, though the temperature rise is fairly moderate (about 4°C within one month over 200 m). The highest temperature rise occurred at #1 measurement point, i.e. inside the goaf along the intake gateroad, with an average temperature increase of 0.19°C/d. In the whole test period, there was no occurrence of 1°C/d, indicating the sponcom prone zone in this goaf cannot be determined with temperature measurements alone.

Figure 5 shows the distribution of oxygen concentration inside #4326 goaf. The oxygen concentration reflects the ventilation air flow velocity and seam gas accumulation which are related to strata re-consolidation. In terms of the sponcom risk inside a goaf, the goaf area behind a longwall face is often divided into three zones, namely high (air flow) velocity zone (low sponcom risk), critical velocity zone

Table 1 - Measured temperature and oxygen concentration in #4326 LTCC goaf

Distance inside goaf m	#1		#2		#3		#4		#5		#6		#7	
	O ₂ %	T °C	O ₂ %	T °C	O ₂ %	T °C	O ₂ %	T °C	O ₂ %	T °C	O ₂ %	T °C	O ₂ %	T °C
15	20.7	25.6	17.7	25.6	17.6	25.7	17.1	25.7	17.3	25.7	17.8	25.7	20.7	25.7
20	20.4	26.1	17.4	26.2	16.8	26.2	16.5	26.3	16.9	26.2	17.5	26.1	18.6	25.8
25	18.9	26.4	16.1	26.3	16.1	26.3	15.4	26.4	15.8	26.5	16.1	26.2	18.3	26.1
30	18.4	26.7	15.7	26.8	15.2	26.9	14.7	26.9	14.9	26.7	15.2	26.3	17.2	26.3
35	17.6	26.9	15.5	26.9	14.5	26.9	13.5	27.1	14.1	26.9	14.7	26.4	15.5	26.6
40	16.7	27.2	14.9	27.3	13.9	27.3	12.9	27.3	13.2	27.1	13.8	27.2	14.2	27.3
45	16.4	27.3	13.6	27.4	13.6	27.4	11.9	27.4	12.3	27.4	12.3	27.3	14.7	27.4
50	15.8	27.6	12.1	27.5	11.9	27.8	11.5	27.8	11.8	27.6	11.8	27.5	13.8	27.5
55	15.8	27.7	11.7	27.6	11.1	27.9	10.7	27.6	10.5	27.7	10.9	27.6	11.6	27.7
75	14.6	27.9	9.82	28.1	9.32	27.9	9.43	27.9	9.84	27.8	9.95	27.9	10.3	27.8
100	14.3	28.3	7.23	28.3	6.93	28.4	6.23	28.5	6.73	28.5	6.86	28.3	9.7	28.3
150	10.1	29.6	6.89	29.4	5.92	29.0	5.89	29.2	6.26	29.2	6.5	28.6	6.6	28.3
200	6.2	29.1	6.15	29.2	5.95	29.3	5.74	28.7	5.37	29.1	5.73	28.3	5.97	28.1

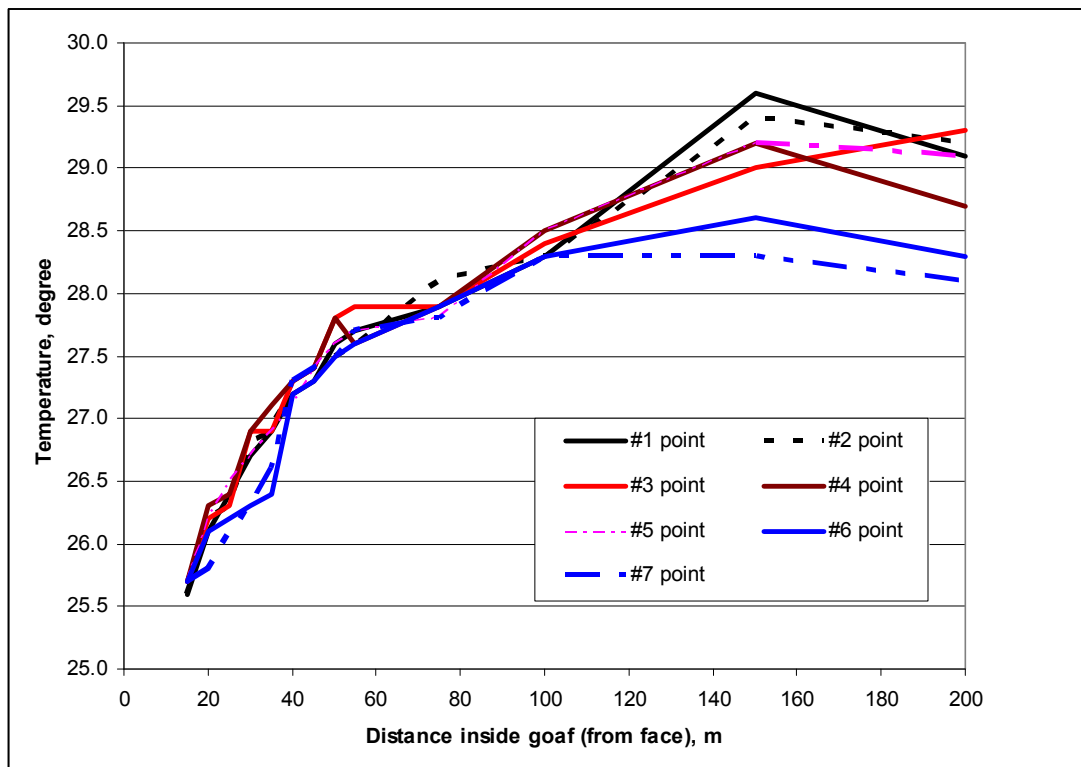


Figure 4 -Temperature variations inside #4326 LTCC goaf with face retreat

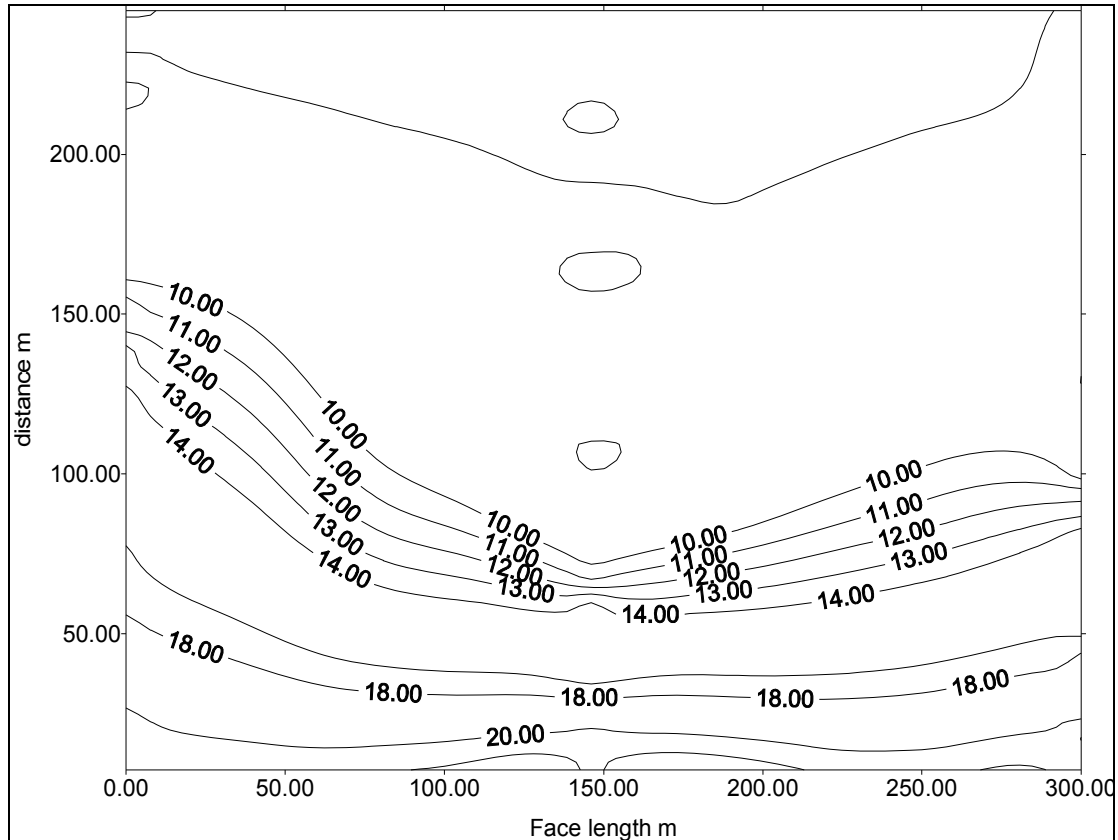


Figure 5 - Contour of oxygen concentration inside #4326 LTCC goaf

(high sponcom risk) and low (air flow) velocity zone (low sponcom risk). In the case #4326 goaf, the three zones were derived from Figure 5 and shown in Table 2.

Table 2 - Three zones inside #4326 LTCC goaf

Zone	high velocity	critical velocity	low velocity	width
goaf along intake gateroad	0-35.3 m	35.3-160 m	>160 m	10-20 m
goaf behind face	0-14.6 m	14.6-75 m	>75 m	260-280 m
goaf along return gateroad	0-28 m	28-100 m	>100 m	10-16 m

Results from Table 2 indicate that the high sponcom risk zone in #4326 LTCC face is quite extensive. The goaf zone along the intake gateroad is quite long (35.3-160 m range). This is because of the high permeability in this area due to pillar support and the continuous fresh air feed from the intake. The goaf zone along the return gateroad is relatively shorter in comparison with that along the intake gateroad (28-100 m range) because of relatively low oxygen concentration from a small amount of air leakage into the area. The high sponcom risk goaf zone in the middle of the face is restricted to the area 15-75 m behind the face.

The identification of the high sponcom risk zone from the test can be used to manage sponcom risk. For example, it can be used to calculate the minimum mining rate by taking account of the incubation period of the seam and the extent of the zone. In the case of #4326 LTCC face, the minimum monthly mining rate for minimising sponcom risk was calculated as 170 m.

CONCLUSIONS

The main conclusions drawn from the field test are summarised as follows:

- A new technique has been developed for directly measuring the temperature and oxygen concentration inside a LTCC goaf, and the technique has been successfully applied in #4326 LTCC face of Xinglongzhuang mine.
- Results from the measurements can be used to identify the sponcom risk zone inside the goaf.
- Locating the high sponcom risk zones inside an active goaf should rely on oxygen concentration

- distribution, with temperature measurements as an auxiliary method.
- In the high sponcom risk zone in a LTCC face, the goaf areas along the intake and return gateroads are longer than that along the middle of the face.

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