Outbursts of Coal and Gas and Preventive Measures

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Abstract

Since the year 1878 when the first recorded coal and gas outbursts in the world occurred, in Fontanes colliery, France, a century has passed. In the course of a hundred years, the frequency of outburst incidences has decreased to a certain extent, because of various studies and attempts for preventive measures. But over the recent years incidences of outburst occur every year in Japan.

And it has been said that no established theories regarding causes, mechanisms and preventive measures are available. But we are of the opinion that at least one of the reasons for the high incidence of outburst is because of the failure to include blasting effect as an important cause of outburst incidence.

In the present paper the relationship between coal and gas outbursts and blasting destruction was discussed, and an attempt was made to explain that in all cases the use of overcharging is a fatal.

1. Forward

Outbursts of coal and gas is a phenomenon which involves a spontaneous outburst of a large amount of methane gas accompanied by a tremendous volume of pulverized coal and shattered bedrock at the face of a drifting road way or long wall face.

At times, as a result of such outbursts miners working in the vicinity are buried, asphyxiated or if the gas is ignited a terifying gas explosion may even occur.

Hitherto, it has been explained that this phenomenon is attributable to high gas pressure or rock pressure, however there are only a few researchers who have explained that the outburst phenomenon is mainly caused by blasting. In some cases it has been stated that blasting causes concussion in the coal seams and moreover gives rise to destruction which induces outburst and that even when outbursts are not induced, safety conditions can be produced by removal of concentrated stress point, however there are no decisive statements to the effect that the above are the direct causes[1),2),3)]. While there are reports that have it that inducer shotfiring may act as a direct preventive method, we can hardly believe that any researcher would state that inducer shotfiring is a mistaken preventive method[4)].

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2. The pheonomenon of coal and gas outbursts

The phenomenon of coal and gas outbursts is mainly seen under drift-working conditions and in rare cases under long wall working conditions and almost never where mining work is at rest.

As an omen or presign several days before or several hours before, rock cracking sounds, an increase in gas emission, an increase in roof rock pressure, swelling or protuberance of the coal face, exudation of water may be seen but at times the outbursts may occur without warning. It has been noted that the texture of the coal at outburst sites are fragile and weak. In the case of outbursts a thunder like rumbling of rock cracking sound or a machine gun like stacato sound, followed by a tremendous amount of gas and coal dust outbursts and a sudden gust of wind occurs, at the same time galleries in the vicinity are completely blocked with crushed coal.

After an outburst of coal and gas, accompanied by a slow rumbling of rock cracking, coal face walls continue to crumble and at the time of the outburst most of the gas is expelled, however in large scale coal and gas outbursts since it is connected with a fault, there are times when gas continues to flow out for more than several days. When the amount of outburst gas is large, the gas is pushed out to the intake side of the ventilator and it is not infrequent that the mine shafts and drift ways become critically dangerous.

3. Actual cases of coal and gas outbursts

Fig. 1[5] shows a recording of CO_2 gas outbursts at the Ferdinand seam of the Ruben Colliery. Work at this seam was discontinued on April 4, 1916 on account of a gas outburst. Work was resumed on Jan. 10th 1918 and gas outburst occurred on the 11th the following day, and the amount of coal outburst came to 998 coal truck loads. This was followed by 120 coal truck loads on Jan. 30th and drift work was carried on by inducer shotfiring which produced 890 truck loads on Feb. 5th. The figure depicts the residual cavity of outburst and driftwork.

As may be seen in the recording, the most interesting and important fact here is that even though the gas outburst on Jan. 11th is connected with the fault, this could not and did not prevent the incidence of gas outburst on Feb. 5th and on March 4th. In the same manner the gas outburst on July 9th 1918 which was connected with a fault, did not prevent the gas outburst which arose on July 22nd. Further along this line, the gas outburst on June 17th, June 30th and that of July 9th while all being only a few meters apart could not prevent the next gas outburst, seems to indicate that sufficient degassing could not be expected. Namely even if advance bore holes are made in close proximity, they are insufficient in their effect.

Fig. 2[5] shows the CO_2 gas outbursts at the Anton seam of the Ruben Colliery. The mid lower portion of the figure shows the drift as a horizontal drifting in the coal and the drift on the right hand of the figure shows a rising drift with an 18° gradient.

As is apparent, the gas outburst in a horizontal drift is of a smaller scale while that of a rising drift is of a large scale. Further in a rising drift, it is

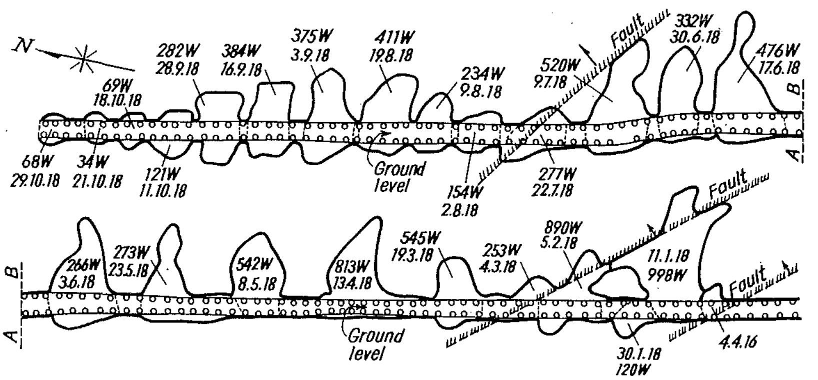

Fig. 1.[5] Outbursts of CO_2 in Level Gallery of Ferdinand Seam, Ruben Colliery (by Wilson)

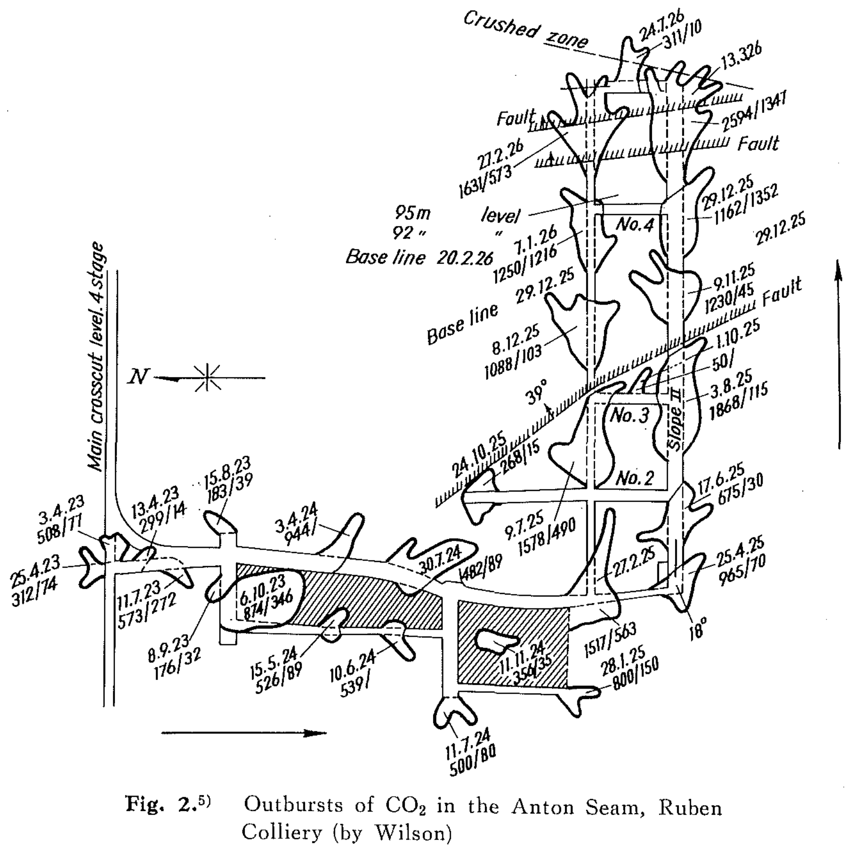

Fig. 2.[5] Outbursts of CO_2 in the Anton Seam, Ruben Colliery (by Wilson)

clear that since the residual cavity of the gas outburst appears in a hand like fasion or baseball glove like fashion it may be deduced that shotfiring was done at the wrist portion. This also seems to indicate the direction of the shotfiring force. We are of the opinion that in the case of rising drift, the force of the shotfiring is augmented by gravity action.

In collieries in Japan since the first coal and gas outbursts occurred at the Miike Yotsuyama Coal Mine in 1926, gas outbursts have frequently occurred in deep drifts in Kyushu and Hokkaido collieries. Of these the most disasterous incident in Kyushu Japan occurred in November 1951 at the Mitsubishi Hajima Coal Mine No. 6 Level. When a cross cut drift reached the coal seam an extensive coal and gas outbursts involving 100,000 m^3 of outburst gas volume, 600 ton spewed pulverized coal volume and 5 cases of asphyxiation occurred. This seems to be the result of an extra high gas pressure at the time when the cross cut drift reached the coal seam, and for the purpose of drift working the shotfiring charge was large and this had a tremendous impact on the seam and it also indicates that a fault was involved.

Table 1.[6] gives the recorded incidences of coal and gas outbursts in various collieries in Hokkaido from around 1927 through to 1970.

It may be noted that coal and gas outbursts are seen mostly from the middle to the northern district in the Ishikari coal Fields, while there are only a few cases in southern collieries. The collieries to the north have coal bearing formations consisting of hard bedrock and complex geological structure.

Generally the volume of gas outburst amounts to 50–100 m^3 and in most cases the amount of pulverized coal is 10–15 t or thereabout. However, the volume of gas and the amount of pulverized coal are not directly proportional. The ratio of gas volume to outburst coal is 2–5 m^3/t with an average value of 2.5 m^3/t and it may be said the volume is not so large. The largest coal and gas outburst seen in Hokkaido occurred in May 1969 at the Utashinai Coal Mine where the gas volume was 140,000 m^3 and the pulverized coal volume was ap-

TABLE 1.[6] Incidences of Coal and Gas Outbursts in Hokkaido Coal Field, Japan

Coal Mine	Number of Outbursts	Coal Mine	Number of Outbursts
Mojiri	5	Mitsubishibibai	38
Akabira	82	Shinhoronai	9
Toyosato	44	Horonai	6
Utashinai	156	Ponbetsu	3
Kamiutashinai	65	Oyubari	4
Sorachi	8	and others	5
Sunagawa	88		
Naie	11	Total	524

* (1926～1970)

proximately 2,500 t (3,000 m^3). The ratio of the Utashinai outburst was 56 m^3/t, and it may be noted that extensive outbursts are generally connected with faults and it may be considered as the total volume of gas flowing out and accumulating over several days while the direct spontaneous emission is not too large.

4. Cause of coal and gas outbursts

When viewed from sites where the possiblity of coal and gas outbursts are high.

1) Where the coal seam and bedrock is fragile and weak.

2) Where the coal seam is fragile and weak and where the bedrock is hard and where the coal seam and bedrock seperate readily.

3) Where the seam is at a steep dip and the cross cut heading is on the verge of the coal seam.

4) At the heading of a deep road way.

5) At a rising heading.

And when cases of coal and gas outbursts are viewed, it would not be necessarily correct to conclude that such incidences occur where the gas volume ratio to that of pulverized coal is larger than normal places.

When the blasting has a excessively strong effect on a fragile and weak site containing a considerable amount of gas where drift working is under way, the blasting causes an impacting compression destruction.

While generally coal and rock have a high resistance to compression destruction, destruction does not occur but when a partial restriction is present by hard rock where the coal seam is fragile and weak, the coal is destructed with the concentrated blasting force and becomes more pulverized. When pulverization occurs gasification occurs violently, gas and pulverized coal bursts out of a new heading face.

The reason why the possibility of incidence of outburst is high in a rising drift is due to the fact that the self weight of the seam has an enhancing effect on the gas outburst and for the same reason in steeply inclined seam the possibility of incidence of outburst is high.

The incidence of outburst rises immediately following blasting, however at times an outburst may occur after a lapse of several hours. This is due to the fact that the direction of the outburst is in opposition to the blast force direction. While the pulverized coal is temporarily compressed by blast pressure, with the advance in gasification several minutes later the outburst comes pushing back. The excavated coal which is in the drift immediately after the blasting suppresses the new heading face which causes a temporary delay of the outburst. In such a case, as the blasted and piled coal at a drift heading is carried away, the coal face of drift heading is often pressured out.

The rock cracking sound which is an presign of an outburst may arise as a result of blasting in front and at times even when rock cracking sounds are heard, gas outburst may not occur.

When the gas pressure is high, or when the blast pressure is intense the outburst becomes increasingly larger and becomes more spontaneous. Especially when a cross cut drift reaches a seam, when the blasting to the rock is carried out if the charged hole tip is in the coal seam, the probability of an outburst is extremely high.

In a rising, the reason why the outburst is on a large scale is not only due to gravity action since the pulverized coal of outburst is shot out for a considerable distance and heading is not suppressed by excavated coal, the possibility of overcharged blasting is extremely large. Further in a rising drift work even though the blasting work efficiency may be enhanced, if an overcharged blasting is made it may lead to localized degradation and in edgewise a drift work of this kind, danger is imminent.

5. Means to prevent coal and gas outbursts disaster

(1) Prevention of gas outburst and counter measure to avoid disaster.

The following should be carefully observed.

1) Gas outburst danger areas should be designated.

2) Drifts should be made as wide as possible and drifts should not be advanced rapidly. A slow proceeding reduces the destruction of gallery walls.

3) Instead of a rising along a seam the drift workings should be made downwards. This would negate the pull action of gravity.

4) When a rising along a seam must be made upwards inevitably, a large diameter bore hole should be made so that the upper drift and lower drift will be connected, and the drift should be made along this bore hole. This decreasses the forward destruction force of the blast.

5) In the case of horizontal drift working the advance bore hole should be of a large diameter and a through degassing should be made. This reduces the gas pressure.

6) Blast drift working should be used only when absolutely necessary and other drift working methods should be adopted.

When forced to use blast drift working, the following listed points should be strictly adhered to, to avoid outbursts and the blast charges should be made as small as possible.

1) The drilling length of charge hole should be shortened to avoid destruction of forward coal seams.

2) The charge of explosives per a hole should be made as small as possible to limit the area of forward destruction.

3) The drill hole numbers per cross section of 1 m^2 at the digging face should be minimized.

4) Special care should be taken when a cross cut reaches a coal seam, and when a coal seam is present at the end of a drill hole the seam should be

blocked by tamping and the blast force should be cut off from the seam to the rear.

5) The following should be strictly avoided. Even though a fault or a fragile and weak point can be readily blasted, the drill hole should never be over extended, and because the anticipated effect may be heightened, it should be remembered that the charge should never be made large.

In the event that a coal and gas outbursts should arise, in order to minimize the disaster, the following should be observed.

1) Shelters should be set up at various strategic points.

2) Dependable power cut off switches should be installed.

3) Warning and communication apparatus should be installed.

(2) Inducer shotfiring and advanced boring.

Hitherto inducer shotfiring and advanced boring have been used as preventive measures against gas outbursts, however the fact that these methods have not been sufficiently effective is because it was unknown whether blasting itself can be the direct cause of gas outburst.

1) Inducer shotfiring has been widely used from away back, however it has not been noted that inducer shotfiring is generally used at the rear with a large charge and in all cases is dangerous. Therefore when an outburst occurs, since it was considered that it would be safe till the next outburst, but since blasting gives a seam compression stress, strain, destruction and gas desorption which may push back after a time lapse, unexpected outbursts may occur, and unexpectedly large scale coal and gas outbursts may be induced leading to unexpected large scale disasters.

2) Regarding advanced boring, with the development of deep or long depth drilling technics, a large portion may be degassing but not be completely. And when the next blast drift working is made, instantaneously the drill hole entrance is destroyed and degassing becomes impossible. Because of this a gas outburst results and it is not infrequent that a drill hole is seen in the remains of an outburst.

The drilling should be made by a large diameter bore hole in such a way that destruction of the drill hole can not be presented, and at the same time blast drift working should be stopped and if inevitable, it is absolutley necessary that the blast charge should be made as small as possible.

6. Conclusive remarks

We have discussed the causes of coal and gas outbursts, and have outlined preventive measures.

The main three causes of coal and gas outbursts are existance of fragile and weak rock (for example, sootlike coal, the coal and rock in vicinity of faults or those degenerated by volcanic rock), gas pressure and blasting power.

As to the former two discussions have been made hitherto however regarding the third item, mistaken concepts have led to mistaken judgements. Thus, the problematic issues of coal and gas outbursts have been complicated.

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