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Significance of ventilation system design on fire with special reference to extensive and fire affected mine

In a coal mine when sealed off area having connection with atmosphere (surface) and intake airways only the condition becomes more worsen when active fire in such sealed off area creates sufficient drought due to fire. In such situation sometimes pressure created by the fan may not be sufficient to neutralize such suction pressure created by the fire. In this case continuous feeding of fresh air to the fire takes place through cracks and fissures and weak zones around the boundary, which guides the fire to propagate in mines. Continuation of such phenomena for longer period may lead to loss of huge property as well as the mine itself.

To control the leakage of air under such situation some modification in ventilation system is definitely required. In this paper the ventilation arrangement to neutralize the drought created by the fire in one of the mine of BCCL without affecting the ventilation of other part of the mine followed by thorough monitoring of status of fire have been discussed.

Introduction

Conventional ventilation system of mine having few entries and fan installed at the surface only take care for the dilution of the pollutants, heat removal and provides good environmental condition at the working places in mines. Sometimes, it creates excessive pressure differential across the sealed off area, particularly those situated between intake and return airways. The excess pressure differential is neutralized by world wide accepted technique i.e. dynamic balancing of pressure. Apart from this there are some situation prevailing in the mine when sealed off area having connection with atmosphere (surface) and intake airways only. The condition becomes more worsen when active fire in such sealed off area creates sufficient drought due to fire. In this situation sometimes cumulative pressure drop created by the fan may not be sufficient to neutralize such suction pressure created by the fire. In this case continuous feeding of fresh air to the fire takes place through cracks and fissures and weak zones around the boundary, which guides the fire to propagate in mines. The existing ventilation system may not be helpful to tackle the situation. Continuation of such phenomena for longer period may lead to loss of huge property as well as the mine itself.

To control the leakage of air under such situation some modification in ventilation system is definitely required. In this paper the ventilation arrangement to neutralize the drought created by the fire in one of the mine of BCCL without affecting the ventilation of other part of the mine followed by thorough monitoring of status of fire have been discussed.

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Particulars of the mine

Sendra Bansjora colliery a unit of Sijua Area, Bharat Coking Coal Limited, is suffering from acute problem of active fire in VI seam of no. 3 pit. It is situated about 20 km east from Dhanbad railway station. It is developed along top and bottom section in VI seam. The mine, having huge amount of coal reserves, is producing 300 tonnes of prime coking coal per day from seam V only. No. 3 pit is also connected to no. 4 pit via VII seam and IX seam which has already been exhausted. The mine is being ventilated by PV- 200 fan situated at air shaft sunk up to IX seam. The schematic ventilation layout of the whole mine is shown in Fig.1.

In this mine there is an active fire affected area in VI seam top and bottom sections at $7\frac{1}{2}$ L between 29R to 20R and is isolated by altogether 28 stoppings. Sampling pipes are provided in stopping nos. 3, 6, 7, 12, 13, 14, 16, 17 in bottom section and 1 and 4 in top section.

Investigation carried out

Ventilation investigation

Ventilation investigation was carried out in the mine to collect data for simulation of ventilation network and designing of a suitable ventilation scheme to control the fire of VI seam without affecting ventilation of other workings.

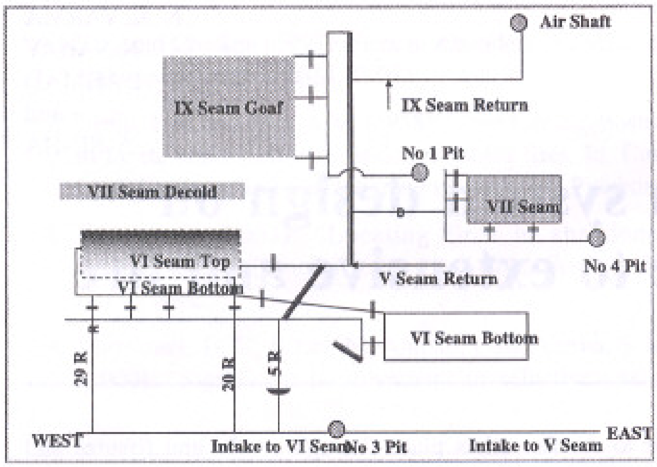

Fig.1 Schematic ventilation layout of Sendra Bansjora colliery, BCCL

The investigation comprises:

- Pressure survey
- Air quantity survey
- Study of performance of main fan and
- Fire area stoppings behaviour

Pressure survey

Pressure survey was carried out from no. 3 pit top to fandrift of the mine by "hose and trailing method" using recently calibrated instruments viz. incline manometer, pitot tubes etc. In fact, about 2 km airway was covered along intake and return for this purpose. Pressure of goaf in VI seam was also measured. Pressure results along with goaf pressure are graphically represented in Fig.2.

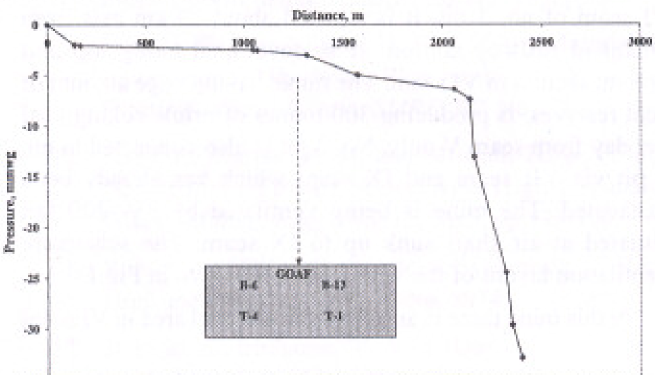

Fig.2 Existing pressure gradient along intake and return airways of the mine

Air quantity survey

Air quantity survey was carried out in the mine using recently calibrated anemometer at strategic locations to ascertain the air quantity distribution in the mine. Results are given in Table 1.

Study of fan performance

During the study, fan pressure and air quantity in the fan drift were measured. Current drawn by the fan motor and voltage were noted from meters provided in the fan house. Results of measurements with other details are furnished in Table 2.

Table 1: Existing air quantities in the mine

	Location	Air quantity, m^3/min
1	Intake to the mine through no. 3 pit	1577
2	VI seam intake	651
3	V seam intake	925
4	VII seam leakage to main fan	200
5	IX seam return to main fan	1327
6	Surface leakage	521

Table 2: Details of fan parameters

Make	Voltas
Model	PV-200
Diameter, mm	2000
No. of blades	8
No. of belts	4
RPM	895
Motor, kW	134
Current drawn by motor, amp	100
Voltage, volts	550
Fan pressure, mmwg	33.0
Air quantity, m^3/min	3626
Power factor	0.84
Air power, kW	19.55
Input power, kW	80.00
Overall efficiency,%	24.50

Study of stoppings pressure and gas concentration

Pressure measurement across few selected stoppings and gas concentration results of air samples are furnished in Table 3.

From Table 3 it is clear that the fire has acquired active stage and created drought of very high value (suction pressure about 19.00 mmwg) over the stoppings of sealed off area. It requires reduction in negative pressure.

The degree of explosibility of the air mixture of sealed off area was assessed using computer programme "Explo" and results indicated that the coordinates of the air mixture lies in non-explosive zone (Xm = -12.38, Ym = - 0.56).

Computer simulation studies

From the ventilation investigations a detailed ventilation network of the whole mine was prepared. The ventilation network of the mine was simulated into computer using VENT programme of erstwile CMRI after satisfying Mc-Pherson criterion of simulation i.e.

$$\frac{\sum \Delta Q/Q}{n} \leq 0.1$$

TABLE 3

Stopping nos.	Pressure, mmwg	Gas concentration,%			
		O_2,%	CO_2,%	CO,%	CH_4,%
B - 6	(-) 19.00	2.80	11.50	0.46	0.30
B - 7	(-) 19.00	18.20	1.90	0.095	0.00
B -14	(-) 18.00	-	-	-	-

where, $\Sigma\Delta Q$ is the sum of the difference in calculated and measured value of air quantity at different locations and n is the number of branches. Several schemes suitable to address the problems were worked out.

The schemes are as follows:

SCHEME 1

The scheme envisages full chocking of VI seam air entry in shaft level by erecting a corrugated sheet stopping. Computer simulation results revealed that the pressure developed is not sufficient to neutralize the drought created due to fire and air quantity flowing through VI seam is not sufficient.

SCHEME 2

Under the scheme fully restricted the VI and V seam air entry in no. 3 pit shaft level by erecting corrugated sheet stoppings. The pressure developed due to these constrictions is just sufficient to neutralize the drought effect of fire area only. Computer simulation results revealed that there is remarkable reduction in air quantity in V and VI seams. Under the circumstances no production is possible from mine. Main fan pressure also increases from 33.0 mmwg to 44.0 mmwg. Air quantity distribution in mine under the scheme is furnished in Table 4.

TABLE 4: AIR QUANTITIES IN THE MINE UNDER SCHEME 2

	Location	Air quantity, m^3/min
1	Intake to the mine through no. 3 pit	906
2	VI seam intake	448
3	V seam intake	458
4	VII seam leakage to main fan	324
5	IX seam return to main fan	1604
6	Surface leakage	665

SCHEME 3

This scheme envisages installation of PV-120 fan at appropriate location in top section in 19R between -4 and -3 L and provision of regulator in 28R between -6EL and -6WL. The purpose of installation of this fan was to reduce the pressure outside the fire area.

The results of computer simulation studies revealed that pressure in fire area reduced by 27.0 mmwg without affecting the air flow in other parts of mine including VI seam. Further no effect in main fan pressure was found. Air quantity distribution in the mine under this scheme is furnished in Table 5.

From Table 5 it is evident that air quantity flowing through different parts of the mine is not affected. Pressure distribution along the mine is shown in Fig.3.

From the pressure gradient it can be seen that only the fire area pressure is reduced and was the ultimate objective for assessment of the status of fire as well as to control the fire.

TABLE 5: AIR QUANTITIES IN THE MINE UNDER SCHEME 3

	Location	Air quantity, m^3/min
1	Intake to the mine through no. 3 pit	1574
2	VI seam intake	639
3	V seam intake	935
4	VII seam leakage to main fan	200
5	IX seam return to main fan	1328
6	Surface leakage	522

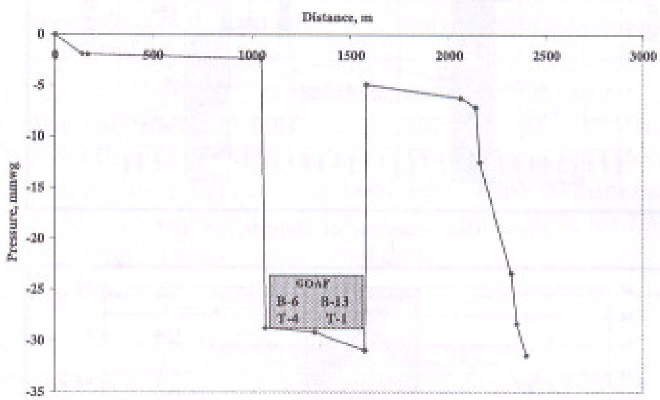

Fig.3 Modified pressure gradient along intake and return airways of the mine

Implementation of the scheme

On the basis of computer simulation studies (scheme 3) the whole area under the fire was converted into a chamber by providing additional 16 ventilation stoppings between intake and return in bottom and top sections both to avoid leakage and to develop desired pressure by a PV-120 fan in the chamber installed at 19R between -4 and -3 L. A regulator was also erected in 28R between -6EL and -6WL.

After making all arrangements discussed above the pressure of the chamber reduced by 27.0 mmwg with respect to outbye of the fire area stoppings (Fig.1). All the stoppings of fire area became positive by 5.0 - 6.0 mmwg and continuous feeding of oxygen to the fire area could be minimized. This system of ventilation arrangement supported in accurate monitoring of status of fire. The efficacy of the system was such that it could not affected the existing air quantity anywhere in the mine as well as no effect was observed on main surface fan as a result of investigation obtained after implementation of the scheme.

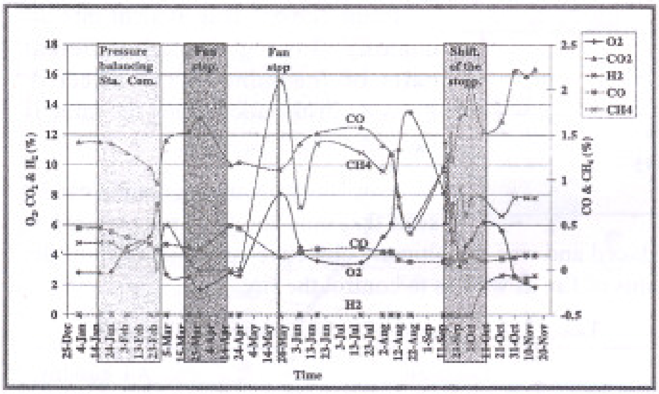

Fig.4a Gas behaviour of stopping no. B-6

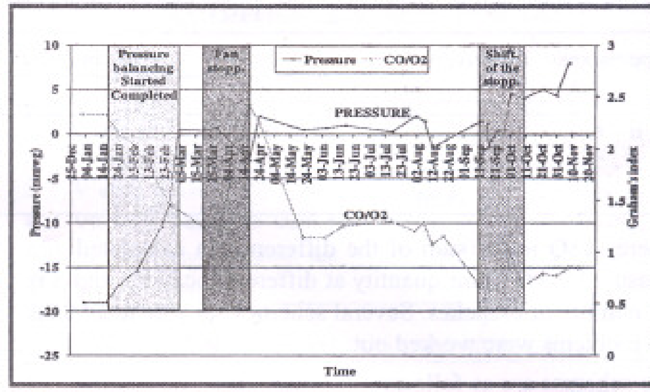

Fig.5a Variation of pressure and Graham's index with time of stopping no. B-6

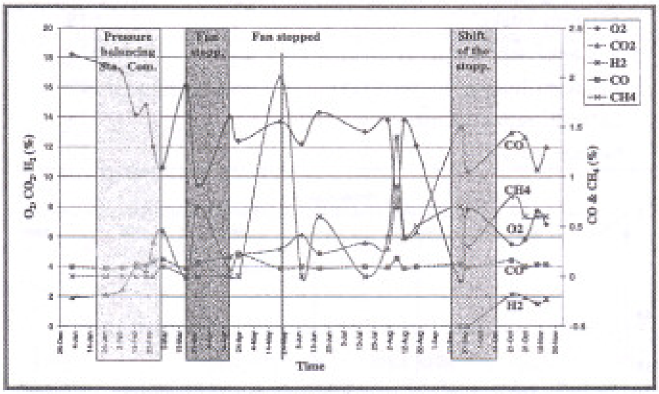

Fig.4b Gas behaviour of stopping no. B-7

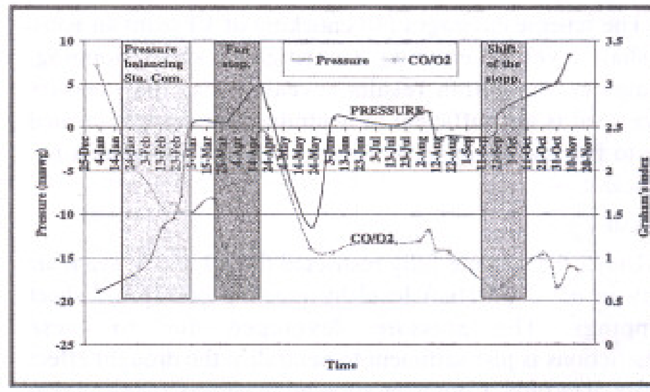

Fig.5b Variation of pressure and Graham's index with time of stopping no. B-7

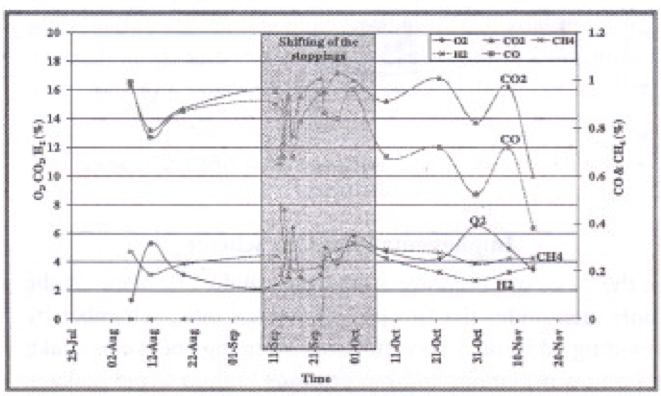

Fig.4c Gas behaviour of stopping no. B-12

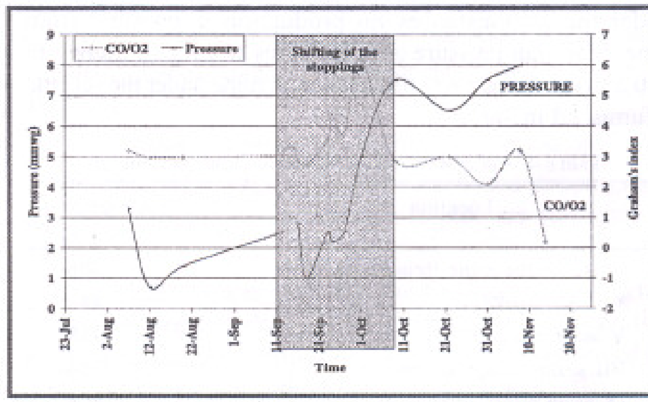

Fig.5c Variation of pressure and Graham's index with time of stopping no. B-12

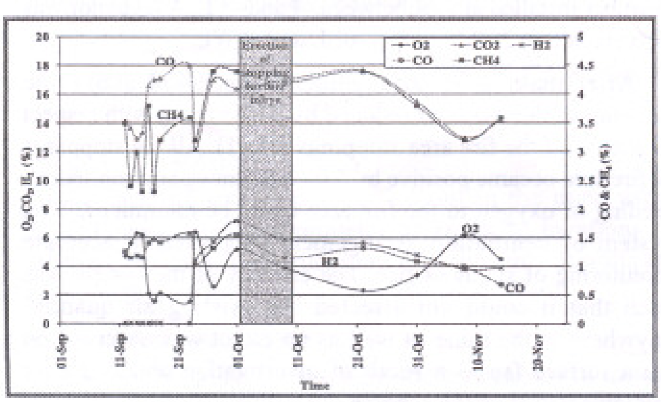

Fig.4d Gas behaviour of stopping no. T-4

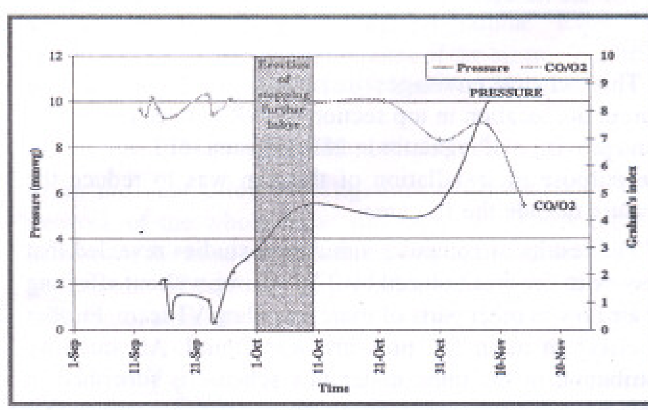

Fig.5d Variation of pressure and Graham's index with time of stopping no. T-4

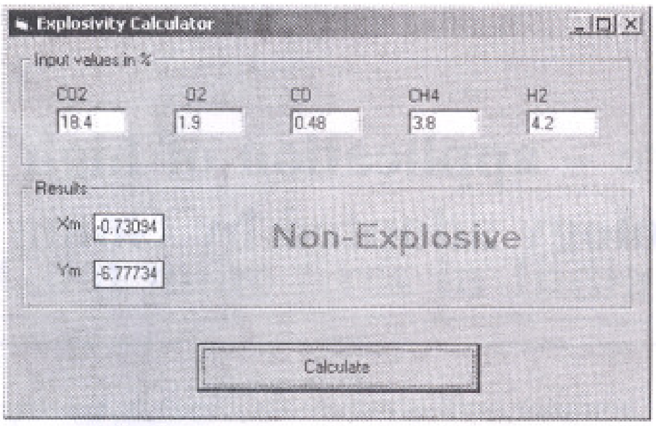

Fig.6 Output screen of the "EXPLO" program

Monitoring the status of fire

The status of fire is monitored generally for assessment of extent of fire and the efficacy of any measures applied. Many fire index ratios are defined for this purpose. In practice Graham's ratio is widely accepted. But in case of monitoring of status of active fire particularly after cutting of supply of oxygen and applying suitable measures, Graham's ratio alone may not be sufficient due to the following reasons:

- In presence of sufficient oxygen complete combustion may take place
- In presence of high temperature CO may oxidized to CO_2 and vice-versa
- After reduction in supply of oxygen burning of CH_4 may not take place leading to built up methane in the sealed off area.

In this situation assessment of status of fire on the basis of Graham's ratio, Young's ratio as well as assessment of explosibilty of gas mixtures using "Explo" programme based on Ellicott's extension of Coward's diagram developed by erstwhile CMRI may prove better representation of the fire.

The graphical representation of the status of fire and efficacy of the measures on the basis of the air sample analysis result collected from different stoppings are given in Figs.4, 5 and 7 below. The output screen of the "Explo" programme is shown in Fig. 6.

Conclusions

Redesigning the ventilation system of fire affected mine from the field investigation data and its subsequent implementation followed by monitoring the status of fire found to be very effective in controlling fire as well as safety in mine. To maintain the positive pressure in fire area stopping, fan in chamber should be in continuous operation and leakage through ventilation stoppings should be properly maintained. The approach is in general enough to apply in other mines under similar situation.

Acknowledgments

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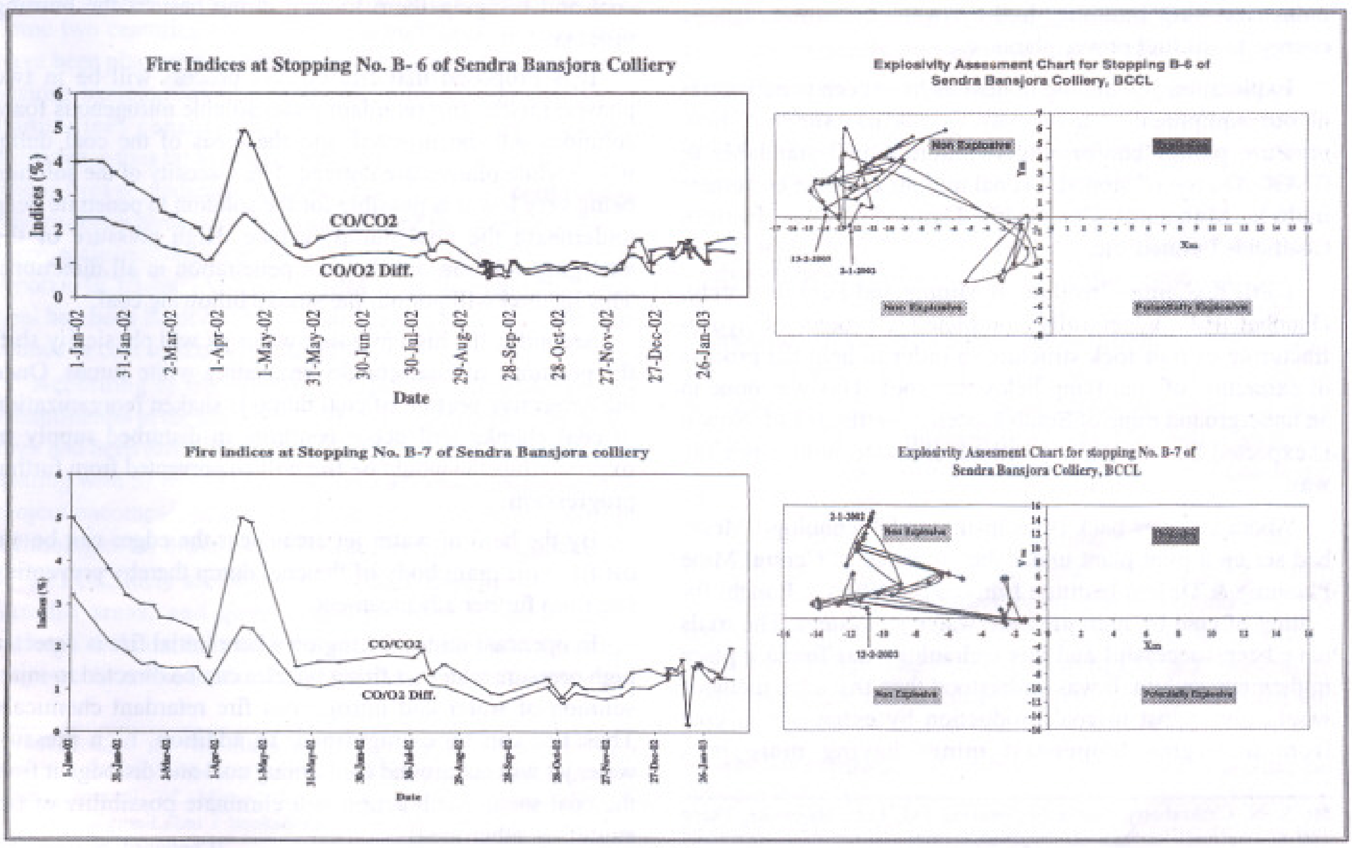

Fig.7