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Planning of Ventilation Requirements for Deep Mechanised Long wall Faces - A Case Study of Adriyala Longwall Project of The Singareni Collieries Company Limited (SCCL)

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Abstract

With near exhaustion of shallow deposits, mining operations are planned to reach greater depths. Coal mining particularly in SCCL has to face numerous challenges for extraction from lower horizons associated with difficult geo-mining and environmental conditions. Suitable mining technology with heavy mechanisation is being introduced to meet the production requirements safely and economically. Mining at greater depth needs strategic planning and execution to overcome the operational problems and issues related to mine environment. Adriyala Longwall Project in SCCL is planned to operate with high capacity Longwall unit at depth range of 300-720m. To maintain comfort work place environment in workings of the mine, it is proposed to establish suitable ventilation system along with air cooling arrangements. This paper gives insight of the details of the project and ventilation system executed to meet the requirements and the proposed air cooling arrangements at the mine.

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Keywords: Ventilation ;Deep Mechanised Longwall face

1. Introduction

The current and the future underground coal mining in the Singareni Collieries Company Limited (SCCL) is making tremendous shift from the previous low capacity to high production mining. With near exhaustion of shallow deposits, underground coal mining has to be taken up at deeper horizons with challenging technological and operational conditions. These operations involve heavy mechanisation with 4MW to 8MW face machines operating at 400 - 600m depth at present and mining depth will be 600 - 1200m in near future. Mines are served by large network of coal conveying systems with installed capacity ranging from 5MW to 10MW. Workings in underground extend to about 4.0 - 8.0km from surface. These high capacity machines, geo-mining conditions and faster extraction rates add substantial heat to working environment.

High capacity underground coal mining is associated with various work places environmental hazards

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such as heavy inrush of inflammable gases and coal dust apart from hot and humid work place conditions leading to prohibitive mining conditions unless concerted efforts are in place.

Advanced technologies, substantial investments and dedicated team work is involved not only in construction and operation of the mine and mining machinery but also required in achieving comfort work place environmental conditions.

To maintain comfort conditions at workplace, air quantity flow is to be substantially increased as primary effort which is considered as the low cost alternative. Apart from improving ventilation intensity, some organizational steps to eliminate sources of heat from intake air can improve workplace comfort.

Under certain conditions, increase of air quantity is possible only to some extent as per design of mine ventilation system. There is also some limitation to increase comfort by increasing the air quantity. Under these circumstances it is required to adopt artificial cooling arrangements for mine air to achieve comfort at workplace for improving production, productivity and safety.

Majority of heat load to mine air in deep underground mines is attributed to increase of virgin rock temperature, heat from machinery and mine water. Coal mining regulations permit mining operations at maximum ambient temperature of 33.5 ^{0}C, for comfortable and productive mining operations, workplace temperature is to be maintained below 28.0 ^{0}C. These conditions can be achieved by using various types of cooling systems to cool the mine air by basically using refrigerating machines.

2. Details of Adriyala longwall project

To meet the increasing demand of coal, SCCL has introduced high capacity mechanization in underground mines at deeper horizons. As part of the mission, high capacity Longwall technology is installed at Adriyala Longwall Project (ALP) with production capacity of 2.817 Mtpa.0

Adriyala Longwall Project is located in Ramagundam Coal Belt of Godavari Valley Coalfields in Karimnagar District of Telangana State. Nearest Railway Station is Ramagundam which is about 25km from the project. This project is equipped with new generation Longwall technology and it is the first of its kind to be introduced in Indian coal mines.

2.1. Salient features of the mine

Workable seams	:	I, II, III and IV
Seam thickness	:	I -5.7m II -3.3m III -9.4m IV -3.7m
Gassiness of seams	:	Degree-I
Gradient	:	1 in 5 to 1 in 7
Geological Reserves	:	110 Mt
Extractable Reserves	:	78.597 Mt (Approx.)
Depth range	:	300 - 720m
Length of Longwall panels	:	1800 - 2400m
Width of Longwall panels	:	250m
Distance from surface	:	4500 - 6500m
Capacity (MTPA)	:	2.817
Life of the Mine	:	35 years

2.2. Entries & roadways of the mine

2.2.1. Downcast

Entries made to this mine through highwall of the existing opencast mine (RG OC-II) which are used for transport and downcast. These are driven in coal seam (I seam) by Roadheading machines.

Number of entries	:	4
Length of each drivage	:	1810m (up to dip side gate of first Longwall panel i.e., 68L)
Gradient	:	1 in 5
Dimensions	:	5.5m width, 3.6m high

2.2.2. Upcast

Vertical Shaft was sunk connecting all the seams to use as Upcast of the mine

Depth of the Shaft	:	470m
Diameter of the Shaft	:	7.5m

2.2.3. Roadways

Trunk Roadways	:	4	Intake	(5.5m x 3.6m)
	:	3	Return	(5.5m x 3.6m)
Gate Roadways	:	Maingate		(5.2m x 3.3m)
	:	Tailgate		(5.2m x 3.3m)
Inter-seam Tunnels	:	2 Tunnels		(5.5m x 3.6m)

2.3. Details of production units

- High Capacity Longwall Equipment - 1 unit
- Roadheaders - 4 units

3. Details of longwall panels proposed to be worked in the project

Capacity and installed power of various equipment

Longwall Face including service equipment

Shearer	:	2245 kW	
AFC	:	3 x 850 kW	3000 TPH
BSL	:	400 kW	3100 TPH
Crusher	:	400 kW	
Hyd. Pumps :		3 x 75 kW	
		3 x 200 kW	
		2 x 75 kW	
Total (A)	:	6570 kW	
		4 x 315 kW	
		4 x 315 kW	
Total (B)	:	7740 kW	

Table 1. Details of the Longwall panels proposed to be worked in the project along with rated production and other parameters

Seam	Longwall Panel no.	Length of the panel (m)	Depth range	Distance from surface to entrance of the panel	Production /month
1 Seam	LWP-1	2333	350 - 450	1500	2.8LT
	LWP-2	2143	460 - 505	1818	2.6LT
	LWP-3	1854	517 - 560	2136	2.3LT
	LWP-4	1832	570 - 610	2640	2.3LT
2 Seam	LWP-1	2333	371 - 471	1775	2.8LT
	LWP-2	2143	481 - 526	2093	2.6LT
	LWP-3	1854	538 - 581	2411	2.3LT
	LWP-4	1832	591 - 631	2915	2.3LT
3 Seam Top Section	LWP-1	2333	441 - 541	2143	2.8LT
	LWP-2	2143	551 - 596	2461	2.6LT
	LWP-3	1854	608 - 651	2779	2.3LT
	LWP-4	1832	661 - 701	3283	2.3LT
3 Seam Bottom Section	LWP-1	2333	448 - 548	2173	2.8LT
	LWP-2	2143	558- 603	2492	2.6LT
	LWP-3	1854	615 - 658	2800	2.3LT
	LWP-4	1832	668 - 708	3314	2.3LT
4 Seam	LWP-1	2333	456 - 556	2220	2.8LT
	LWP-2	2143	566 - 611	2530	2.6LT
	LWP-3	1854	623 - 666	2846	2.3LT
	LWP-4	1832	676 - 716	3360	2.3LT

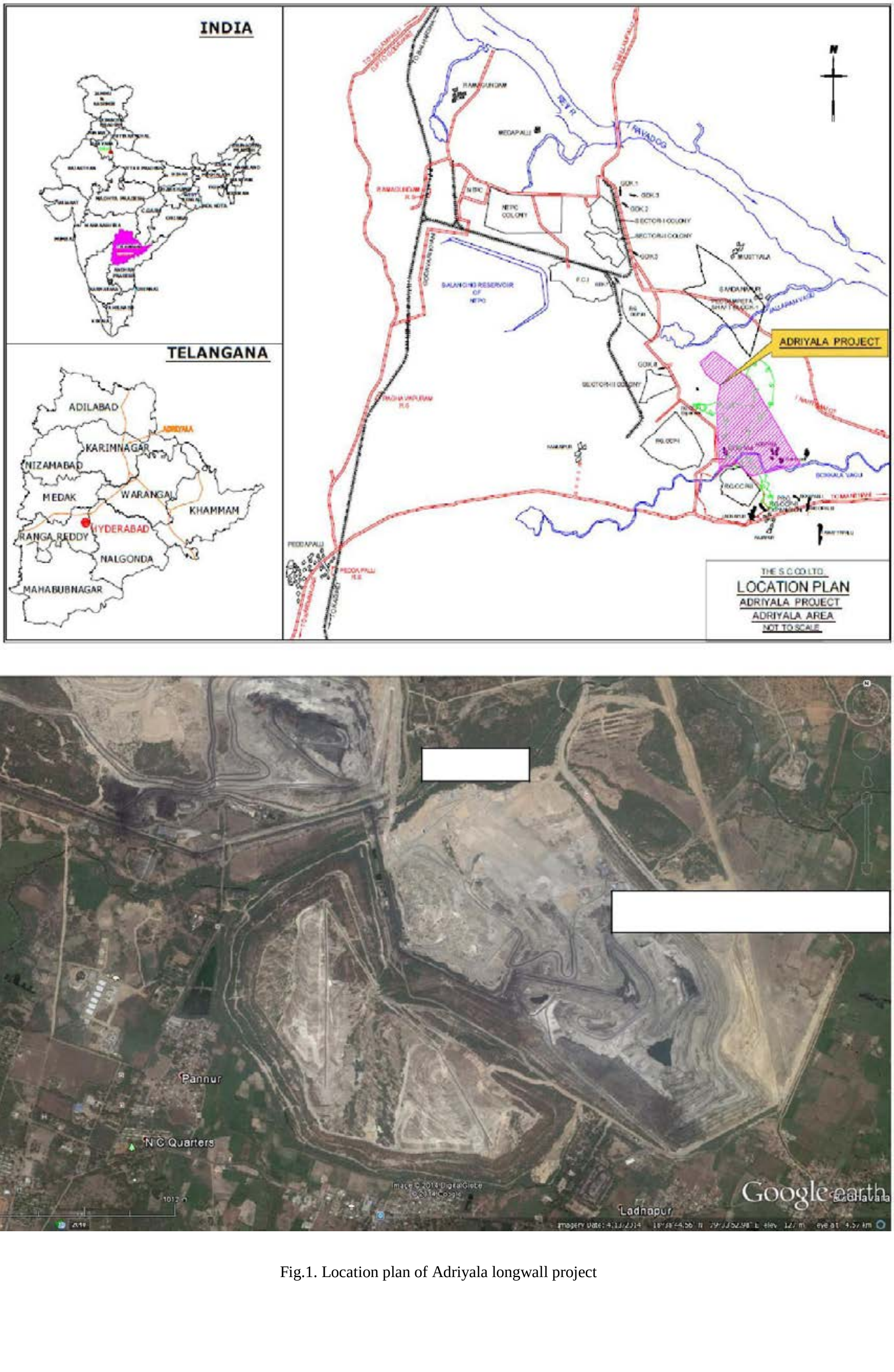

Fig.1. Location plan of Adriyala longwall project

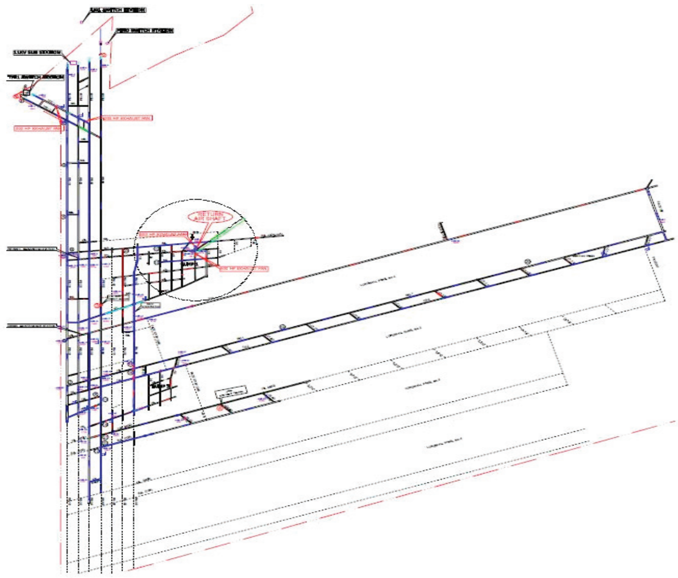

Fig. 2. Mine plan of Adriyala longwall project

4. Planning of ventilation requirements

Three working areas i.e., A: Longwall Panel, B: Gate Roadways Development-I (with 2 Roadheaders) and C: Gate Roadways Development-II (with 2 Roadheaders) will be simultaneously operated in the mine.

Ventilation designing has been carried out by ventilation network modelling and optimisation studies. While designing ventilation system, stipulations of Coal Mines Regulations (CMR), gassiness of seams as well as other environmental conditions at workplace are taken into consideration. Study envisages the details of requirement of air quantity, number and size of entries, proposed ventilation layout and operating pressure, capacity of Main Mechanical Ventilator, requirement of Booster Fans and Auxiliary Ventilation.

4.1. Ventilation system for development of gate roadways

The gate roadways for Longwall panels are envisaged to be driven by Roadheaders. The maximum dimensions of gate roadways are 5.2m x 3.3m (W x H). As the wet bulb temperature is expected to exceed 30.5^{0}C, the minimum velocity of air at the face must be 1.0m/s as per the stipulation of CMR. Therefore, the minimum quantity of air requirement at the face would be 5.2 x 3.3 x 1.0 = 17.16m^3/s.

Length of gate roadways to be driven by, are varying from about 1600m to 2500m. It is difficult to drive roadways of these lengths as blind headings are at higher depth. Hence, all the gate roadways are to be developed by twin roadway development by chain-pillar system by deploying 2 Roadheaders. Adjacent gate roadways of Longwall Panels i.e., Main-gate of upper panel and Tail-gate of lower panel are planned to be driven with interconnections at 200m interval.

Gate roadways are planned to be driven by circulating about 50m^3/s air quantity. One of the roadways will be used as intake and the other roadway will be return. As both roadways are interconnected at an interval of atleast 200m, interconnection will be used as Last Ventilation Connection (LVC) so that at no point of time blind heading to be ventilated by Auxiliary Ventilation will be more than 300m. Auxiliary ventilation (Exhaust) is to be provided by installing the fans in LVC at return gate.

The headings will be ventilated by Auxiliary fan with Steel-reinforced Flexible Ducting having diameter of **1200mm**. To provide required quantity of air at the face, each roadway is ventilated by Auxiliary Fan having capacity of **20m^3/s** at **4.0kPa** pressure (approx 120kW) with twin impellers in series with independent prime (maximum length of ducting connected to the Auxiliary Fan would be about 300m). Auxiliary Fan with twin impellers and separate motors can facilitate use of single impeller when system resistance is low resulting in optimum energy consumption.

4.2. Ventilation system for longwall panel

At the Longwall face, the quantity of air requirement would depend upon the minimum air velocity requirement at the face and volume of gas liberated. Since the mine is classified as Degree-I gassiness, air quantity requirement would depend upon the basis of velocity requirement.

As per stipulation of CMR, the minimum air velocity at maximum span of Longwall face should be 1m/s. With 3.4m of height of extraction and maximum span of around 6.0m, the area is around 20.4m^2 hence, the minimum air quantity requirement at Longwall face would be 20.4 x 1 i.e., 20.4 m^3/s. Keeping in view of high capacity equipment and high productivity operations, about 50m^3/s is planned to be circulated at Longwall Face. Bottom two gates (MG of working panel and TG of lower panel) are used as intake to the Longwall face and the top gate is used as return.

In Gate Roadways development as well as in Longwall panel, Booster Fans of 55kW capacity rated to deliver 50-75m^3/s at 0.8-0.3kPa pressure are used in situation of critical paths of ventilation while workings advanced to a distance of about 1000m from trunk ventilation route.

4.3. Summary of the ventilation requirements of the project

Table 2. Ventilation requirements of the project

Sr. No.	Place of work	Requirement of air quality
1.	Twin gate development-I (2 Roadheaders)	50m^3/s
2.	Twin gate development-II (2 Roadheaders)	50m^3/s
3.	Longwall face	50m^3/s
4.	Conveyor Roadway	25m^3/s
5.	Pumping Stations & Sub-stations	25m^3/s
6.	Total air quantity requirement	200m^3/s

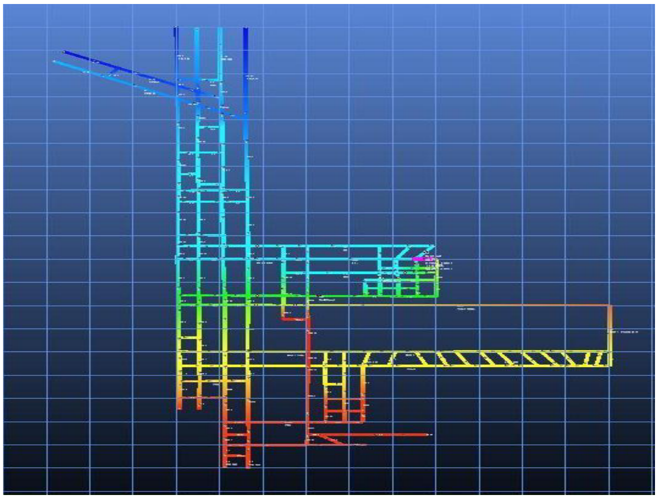

Fig.3. Ventilation network model of Adriyala Longwall Project

Considering the Ventilation Efficiency Quotient (VEQ) of about 85%, the total air quantity requirement for entire mine operations would be about **235m^3/s.**

To meet the above ventilation requirements of the mine, Ø3200mm, 400kW capacity Main Mechanical Ventilator rated to deliver 200-250m^3/s at 1.5-1.1kPa pressure is installed at Upcast Shaft along with equal capacity standby.

While designing the ventilation system of the project, ventilation network modelling was carried out by using Ventsim software to derive optimum ventilation system.

As per the network optimization to meet the above ventilation requirements of the project, Ø3200mm, 400kW capacity Main Mechanical Ventilator rated to deliver 200-250m^3/s at 1.5-1.1kPa pressure is installed at Upcast Shaft along with equal capacity standby.

5. Need for air-cooling system

As the workings are planned at depth of 300 - 720m, Virgin Rock Temperature (VRT) is expected to be 42.5 ^{0}C (Geo-thermic gradient @ 1.0 ^{0}C/50m depth). Temperature at workplaces is expected to be higher than 32.5 ^{0}C even with an air flow of 50m^3/s. Workplace ambient conditions are expected to further deteriorate during mining operations due to high capacity electrical machinery. Separate ventilation split is also planned to be provided for conveyor roadway to avoid heat addition to intake stream of workings.

Though coal mining operations are permitted at maximum ambient temperature of 33.5 ^{0}C, for comfortable and productive mining operations, workplace temperature is to be maintained below 28.0 ^{0}C. Under these circumstances it is required to adopt artificial means of cooling arrangements for mine air to achieve comfort at workplace for improving production, productivity and safety.

Keeping in view of the prevailing conditions, it is proposed to install a suitable Air-cooling system at the mine. Mine air cooling can be achieved by using various types of cooling systems by using refrigerating machines/chillers along with associated ancillary equipment.

5.1. Details of the proposed air-cooling system

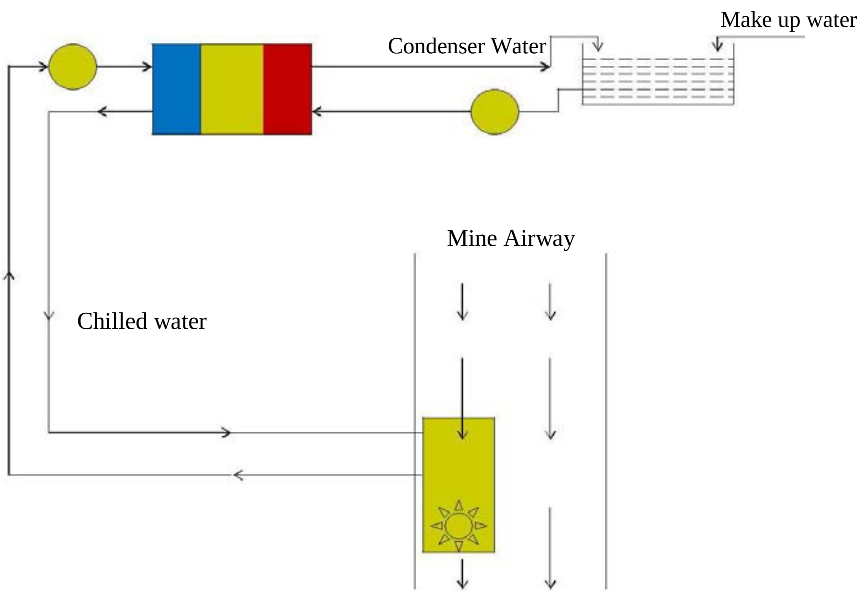

Fig. 4. Schematic diagram of the proposed air-cooling system

- Intake air temperature in three working areas is proposed to be reduced from 32.0^{0}C to 25.0^{0}C for air flow quantity of 150m^3/s (three working areas @ 50m^3/s each).
- The system consists of Refrigeration plant (Chillers) to chill the water in closed cycle. Refrigeration plant will be installed in underground and suitably located considering optimum/high positional efficiency. Eco-friendly refrigerant such as HFC is proposed to be used.
- Condenser cooling is proposed by circulating the water in evaporative cooling towers installed at surface.
- Chilled water is circulated through insulated pipes to the Air Handling Units (AHU's) strategically located in intake of working districts.
- Intake air of 50m^3/s is split into 2 streams of 25m^3/s. Two AHU's will be installed with capacity of 12.5m^3/s each (one AHU in each stream).
- AHU reduces the air temperature from 32.0^{0}C to 18.0^{0}C, mixed air temperature in each air stream will be about 25.0^{0}C-26.0^{0}C.
- Refrigeration capacity requirement is about 1500TR (5.27MW). Refrigeration is proposed to be achieved by installing multiple capacity water cooled screw chillers facilitating to use partial capacity during winter.

5.2. Operational cost of the proposed air-cooling system

- Expected total system power consumption will be about 1830 kW at 100% load.
- Annual energy cost is expected to be about ₹. 8,97,72,480/-
- O&M, Manpower cost would be approximately ₹. 54,75,000/-
- Cost for Air-cooling per tonne of coal production would be about ₹. 31.9/-(exclusive of the cost of consumables & spares)

6. Conclusions

- Due to depleting shallow deposits, underground coal mining in India and particularly in SCCL has to face many challenges to sustain the productivity, safety and economy. Suitable mining technology such as Longwall, Continuous Miners etc. for high capacity underground mining need to be viable and efforts should be made for its success.
- Underground coal mining in SCCL has to face arduous conditions due to complex geo-mining conditions. Apart from difficult geo-mining conditions, highly mechanised deep mining pose typical ambient environmental conditions at work sites such as heat, gas and dust.
- Primary efforts such as increase of air flow and tapping of heat from the heat sources directly to the return can improve the workplace comfort. Under certain conditions, in addition to the primary efforts, it will be required to adopt suitable artificial air-cooling systems to achieve comfortable work place environmental conditions.
- Apart from planning of optimum and suitable ventilation systems, air-cooling systems are also needed to be planned with due consideration of positional efficiency and operational efficiency keeping in view of overall economy of underground mining at greater depths.

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