CONTROL AND MONITORING OF COAL MINE OPERATIONS

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Abstract:

Coal handling plants (CHP) are a critical component in thermal power plants, responsible for the efficient handling, storage, and feeding of coal to the boiler. This project focuses on the control and monitoring mechanisms employed in a coal handling plant to ensure smooth, safe, and uninterrupted operation. The study emphasizes the integration of automation systems such as Programmable Logic Controllers (PLCs), Supervisory Control and Data Acquisition (SCADA), and various types of sensors for real-time monitoring of key processes including coal crushing, stacking, reclaiming, and feeding. These technologies help in minimizing manual intervention, reducing operational delays, and improving plant efficiency.

Keywords: *CHP, SCADA, PLC, Monitoring, Automation*

1. INTRODUCTION

The Goleti Coal Handling Plant (CHP), located in Rebbena district, Telangana, is a vital infrastructure component of the Singareni Collieries Company Limited (SCCL). This facility plays a crucial role in the downstream processing and dispatch of coal extracted from nearby mines, primarily catering to thermal power plants and industrial customers. The SCCL-(Singareni Collieries Company Limited) is the only Govt. coal producing company in the Southern India.The SCCL is presently operating 20 Open cast mines and 24 Underground mines. The Manpower as on 31. 07.2023 is 43614. The SCCL mainly caters to the energy needs of the South India. The Singareni Collieries Company Limited (SSCL) is a Government coal mining company jointly owned by the Government of Telangana and Government of India on a 51:49 equity.

Erdem Ilten, Mehmet Emin Unsal This study presents a real-time toxic gas monitoring and early warning system for underground mines using an Arduino Mega to collect data from sensors measuring temperature, oxygen, hydrogen sulfide, methane, carbon monoxide, and dust density. Sensor data is transmitted via Ethernet to a PLC-based SCADA system for instant monitoring and control. The system monitors gas levels against safety thresholds defined by mining regulations and triggers alarms and ventilation automatically when hazardous conditions are detected.

Laboratory tests demonstrated reliable performance, highlighting the system's effectiveness as a cost-efficient solution to enhance underground mine safety [1].

Haibing Wang, Zhuqing Li This article reviews the current challenges and practices in coal mine safety management, emphasizing the importance of reducing hidden hazards to improve industry safety. By analyzing a wide range of literature, the study identifies key issues and proposes strategic approaches to strengthen safety protocols, aiming to enhance the protection of workers and optimize coal mine production process[2].

Suresh Chandra Ch, P Ajith Kumar, Himam Saheb Shaik This study assesses the Environmental, Social, and Governance (ESG) performance of Singareni Collieries Company Limited (SCCL), focusing on key areas such as carbon emissions, resource utilization, land reclamation, community engagement, labor practices, health and safety, and corporate governance. Using self-evaluation scores and analytical tools, the paper highlights SCCL's initiatives toward sustainable and responsible mining practices, emphasizing the importance of ESG compliance for long-term operational success and stakeholder trust in the coal mining industry[3].

2. OVER VIEW OF CHP

The Goleti Coal Handling Plant (CHP), operated by Singareni Collieries Company Limited (SCCL), is a pivotal facility in Telangana's coal logistics network. Strategically located near the Mancherial–Chandrapur National Highway, it serves as a crucial hub for coal processing and dispatch in the northern region of the state.

Fig.1. Over view of CHP

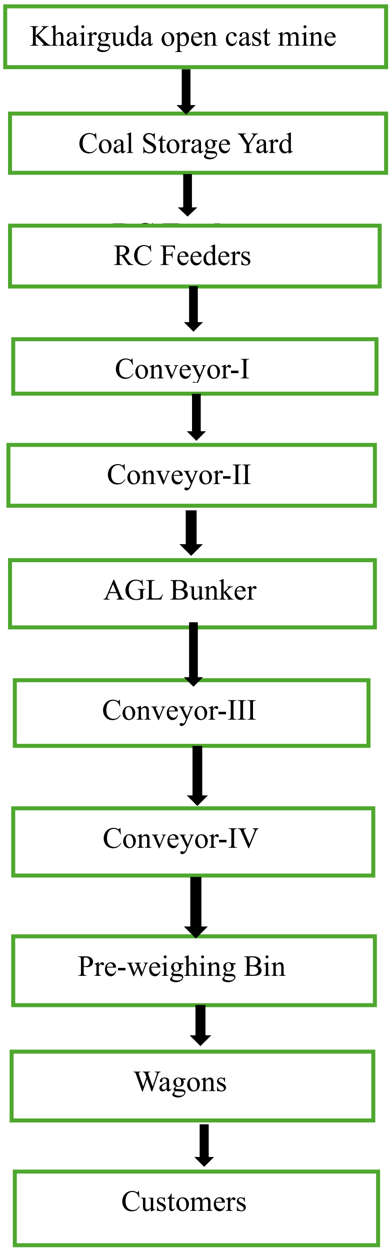
Key Features and Operations Capacity and Throughput: Designed to handle 5 million tonnes per annum (MTPA) of coal, the Goleti CHP achieved a significant milestone by dispatching 3.611 million tonnes in the finacal year 2024–25.

Infrastructure: The facility includes a 6,000-tonne bunker and a pre-weigh bin system,enabling efficient and precise loading of coal into railway wagons. Coal is transported via belt conveyors, ensuring streamlined operations.

Environmental Considerations: Given its proximity to public areas, the plant is equipped with advanced dust suppression systems to minimize environmental impact, adhering to stringent pollution control standards.

2.1 STEP BY STEP PROCESS OF COAL HANDLING PLANT

It explains about the step by step process of Coal Handling Plant from Khairguda open cast mine to customers.



The diagram shown in the image represents the coal flow process in a Coal Handling Plant (CHP), from the source (mine) to the end customer. Here's a brief explanation of each step:

Step-by-Step Process:

Khairguda [Open Cast Mine]: The origin point where coal is mined.

Coal Storage Yard: Temporary storage area where coal is dumped after being mined.

RC Feeders :Equipment used to feed coal from the storage yard onto the conveyors at a controlled rate.

Conveyor-I & Conveyor-II : These are belt conveyors that transport coal to different locations. Conveyor-II takes coal from Conveyor-I and moves it toward the bunker.

AGL Bunker: Acts as an intermediate storage before coal is further conveyed. It helps regulate the coal supply.

Conveyor-III & Conveyor-IV: These conveyors move coal from the AGL Bunker toward the pre-weighing section.

Preweigh Bin: Measures and regulates the weight of coal before it is loaded into wagons. Ensures correct quantity is delivered.

Wagons: Rail wagons used for bulk transport of coal to distribution points.

Customers: The final consumers of the coal — could be industries like power plants, steel plants, or other end-users.

2.2 COMPONENTS INVOLVED IN CHP

- Conveyor belts
- Reciprocating Feeders
- AGL Bunker
- Plough Feeder
- Pre-weigh Bridge
- Wagon
- Induction Motor

i) Conveyor Belts:

Conveyor belt is a continuous moving belt that transports coal from one part of the plant to another. It's a critical component used for efficiently moving large amounts of coal over long distances inside the plant.

ii) Reciprocating Feeders:

In a coal handling plant, a reciprocating feeder is a mechanical device used to feed coal from a bunker or hopper onto a conveyor belt or into a crusher at a controlled rate. Reciprocating feeders are like a controlled push system to feed coal in small, regular amounts.

iii) AGL Bunker:

An Above Ground Level (AGL) Bunker in a coal handling plant is a large coal storage container that is built above the temporarily store coal after it has been unloaded and before it is sent to the wagon.

iv) Plough Feeder:

In a coal handling plant, a plough feeder (sometimes called a flow feeder) is a machine used to remove coal from a conveyor belt and direct it to another location, like conveyors.

v) Pre-weigh bridge:

In a coal handling plant, a pre-weigh bridge is a system used to weigh coal before it is loaded onto trucks, wagons, or transferred to another part of the plant.

vi) Wagon:

Wagon usually refers to a railway wagon (or coal wagon) basically, a large open or closed container used on trains to transport bulk coal from mines to the power plant.

vii) Induction Motor: In a coal handling plant, an induction motor is a type of electric motor used to drive various mechanical systems. Basically, induction motors convert electrical energy into mechanical energy to run equipment.

3.CONVEYORS

In a coal handling plant, conveyor belts are the primary method for moving coal from the Receiving point to various stages of processing and storage. In a coal handling plant, conveyor Belts are crucial for transporting coal efficiently. They transport coal over long Distances and are essential for efficiently handling large volumes. The belts can carry coal over long distances, making them vital for handling large volumes efficiently .Mainly, Coal Handling Plant consists of 4 Conveyor belts. Namely:

1. CH-I (CONVEYOR BELT-I)
2. CH-II (CONVEYOR BELT-II)
3. CH-III (CONVEYOR BELT-III)
4. CH-IV (CONVEYOR BELT-IV)

Conveyor belts offer several advantages, including increased efficiency, improved productivity, reduced labor costs, enhanced safety, and flexibility. They automate material transportation, minimize manual handling, and can be customized to fit specific applications, making them ideal for various industries such as manufacturing, logistics, and construction. Conveyor belts are a crucial component in various industries, offering numerous benefits that enhance operational efficiency and productivity.

3.1 DETAILS OF CONVEYOR BELTS:

Table 3.1 Details of conveyor belts

Types of Belts	Conveyor Length	Belt Width	Belt Thickness	Capacity
Conveyor Belt-I	175m	1400mm	14mm	2x125kW
Conveyor Belt-II	75m	1400mm	14mm	55kW
Conveyor Belt-III	35m	1400mm	14mm	125kW
Conveyor Belt-IV	198m	1400mm	14mm	2x200kW

3.2 CONVEYOR BELT-I

Conveyor Belt-I is a key component in the coal handling system, designed for transporting Large volumes of coal efficiently. It has a length of 175 meters, which enables it to cover a significant distance in the coal movement process. The belt has a width of 1400 mm and a thickness of 14 mm, including its capability to handle heavy and continuous loads. To ensure smooth and powerful operation, it is equipped with two motors, each rated at 125kW providing a combined power of 250 kW.

Fig.2.Conveyor Belt-I

3.2 CONVEYOR BELT-II

Conveyor Belt-II plays an important role in the coal handling process by providing a reliable means of transporting coal over a moderate distance. It has a total length of 75 meters, making it suitable for connecting intermediate points in the coal transfer system. Like the other belts in the system, it features a belt width of 1400 mm and a thickness of 14 mm, which ensures durability and the ability to carry substantial loads. Powered by a single motor with a capacity of 55 kW, Conveyor Belt-II is designed for operations that require less power compared to the primary belts.

Fig.3.Conveyor Belt-II

3.3 CONVEYOR BELT-III

Conveyor Belt-III is a short-distance conveyor used in the coal handling plant, with a length of 35 meters. Despite its shorter length, it maintains a belt width of 1400 mm and a thickness of 14 mm, consistent with the other conveyor belts in the system, allowing it to handle similar load types effectively. It is powered by a single motor with a capacity of 125 kW, providing sufficient power for transporting coal over short distances.

Fig.4.Conveyor Belt-III

3.4 CONVEYOR BELT-IV

Conveyor Belt-IV is the longest and most powerful conveyor in the coal handling plant system, with a length of 198 meters. It is built to handle high-capacity coal transportation over an extended distance. Like the other belts, it has a belt width of 1400 mm and a thickness of 14 mm, ensuring it can withstand heavy and continuous loads. This conveyor is powered by two motors, each rated at 200 kW, giving it a total power capacity of 400 kW, which is the highest among all the conveyor belts listed.

Fig.5.Conveyor Belt-IV

4. SUBSTATION

Defination: A Substation is a part of an electrical generation, transmission, and distribution system. Substations transform voltage from high to low, or the reverse, or perform any of several other important functions.

4.1 OUTDOOR SUBSTATION

An outdoor substation is a type of electrical substation where all the major equipment such as circuit breakers, transformers, busbars, isolators, lightning arresters, and instrument transformers are installed outdoors, without any building enclosure.

Fig.6.Outdoor Substation

Rating of Outdoor Substation:33/3.3KV

4.1 Table-2: Rating of Outdoor Substation

Name of the Equipment	Rating
Lightning Arrester	33kV,10A
Air Break Switch [ABS]	33kV,800A
Horn Gap fuse	33kV
Station Transformer	50kVA,33kV,440V
Vaccum circuit breaker	33kV,1250A
Current Transformer	33kV,100-50/5A
Potential Transformer	33kV/110V
VOLTAMP[Volt amp Transformer limited]	1600kVA,33/3.3kV

4.2 INDOOR SUBSTATION

An indoor substation is a type of electrical substation where all the equipment, like transformers and switchgear, is housed inside a building or enclosure. It provides a safe and controlled environment for electrical equipment, protection it from environmental factors. Indoor substations are often used in cities, industrial facilities, or sensitive environments.

Fig.7.Indoor Substation

Rating of Indoor Substation : 3.3KV/440V/230V

4.2 Table-3: Rating of Indoor Substation

Name of the Equipment	**Rating**
Group main	3.3kV HT
Transformer	3.3kV/440V
OHT Line Control	3.3kV
Transformer Control	3.3kV/440V
Lightning Transformer Control	50kVA/3.3kV/230V

4.3 LAYOUT OF INDOOR SUBSTATION

The image displays a wiring diagram for an "INDOOR SUB-STATION CHP GOLETI." This appears to be an electrical power distribution diagram for a specific facility or area. Here's a brief explanation of the key components and flow depicted in the diagram:

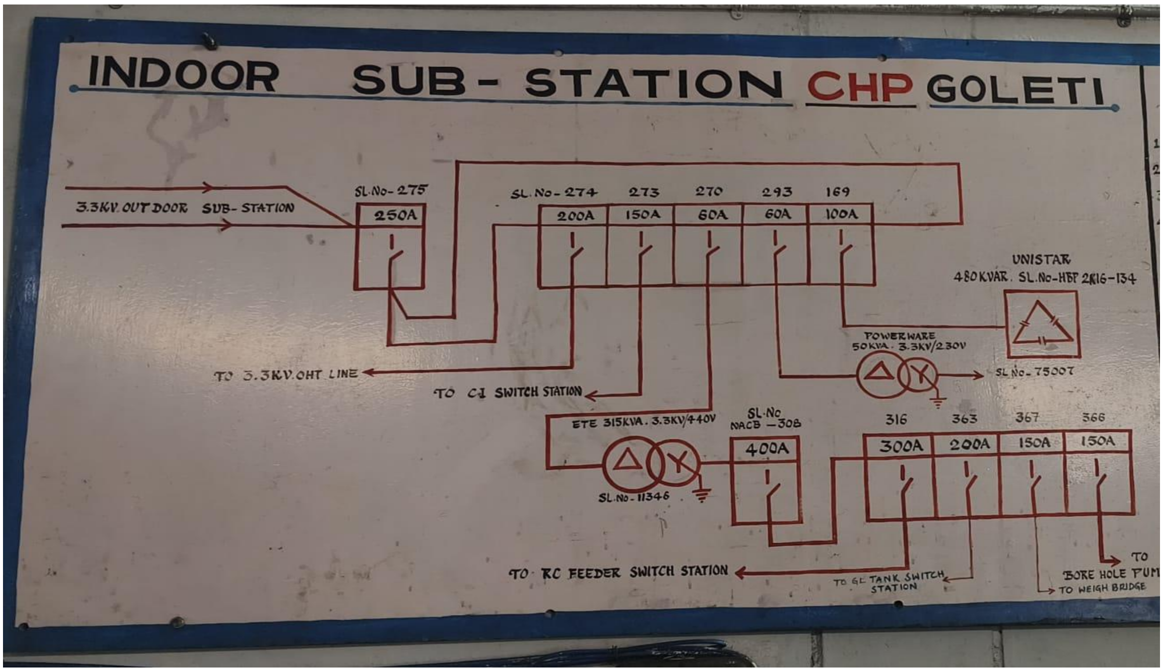


Fig.8.Layout of Indoor Substation

- Incoming Power (Left Side): The diagram starts with a "33kV OUTDOOR SUB-STATION" which is the source of high-voltage power. This power is fed to a "33kV-UNIT LINE" and then to a "33kV CB-750A" (Circuit Breaker, 750 Amperes), which likely acts as the main incoming protection and isolation for the indoor substation.
- Main Distribution (Top Section): After the main circuit breaker, the power branches out to several "SL. No." (presumably "Service Line" or "Sub-Line" numbers) with various current ratings (e.g., 800A, 273A, 270A, 293A, 243A, 189A, 169A, 60A). These are likely feeders to different sections or loads within the facility. There's a component labeled "UNISTAR 480KVAR SL. No.-187, 286-194," which could be a capacitor bank for power factor correction.
- Transformer Section (Middle Right): A portion of the power goes to a "POWER MAX 500KVA, 3.3kV/433V" transformer. This transformer steps down the high voltage (3.3kV) to a lower voltage (433V), suitable for most industrial and commercial applications. From the transformer, the power is distributed via "SL. No." with current ratings (e.g., 3.3kA, 2.0kA, 1.5kA, 1.0kA).
- Feeder Switch Station (Middle Left): Another branch goes to a "SL. No. 33kV-750A" and then splits to "TO CB SWITCH ROOM" and "TO RC FEEDER SWITCH STATION." Lower Voltage Distribution (Bottom Right): The diagram shows further distribution from the lower voltage side of the transformer BORE HOLE PUMP + TO OTHER BUILDINGS." This indicates that power is supplied to various Panel Distribution Boards (PDBs) and other buildings.

5. CONTROL AND MONITORING

The coal handling plant at Goleti utiliszes a SCADA (Supervisory Control and Data Acquisition) system for controlling and monitoring operations. SCADA (Supervisory Control and Data Acquisition) is an industrial automation and control system used extensively in coal handling plants to monitor, control, and optimize the operation of coal transport and processing equipment. It provides real-time data acquisition, centralized control, and process automation, which enhances the efficiency, safety, and reliability of coal handling systems.

Controlling and Monitoring of CHP involves some of the units Namely:

1. Pheonix PLC
2. RIO Panels
3. DAQ Panels
4. A Pheonix Contact VISU+SCADA

5.1 SCHEMATIC DIAGRAM OF CHP

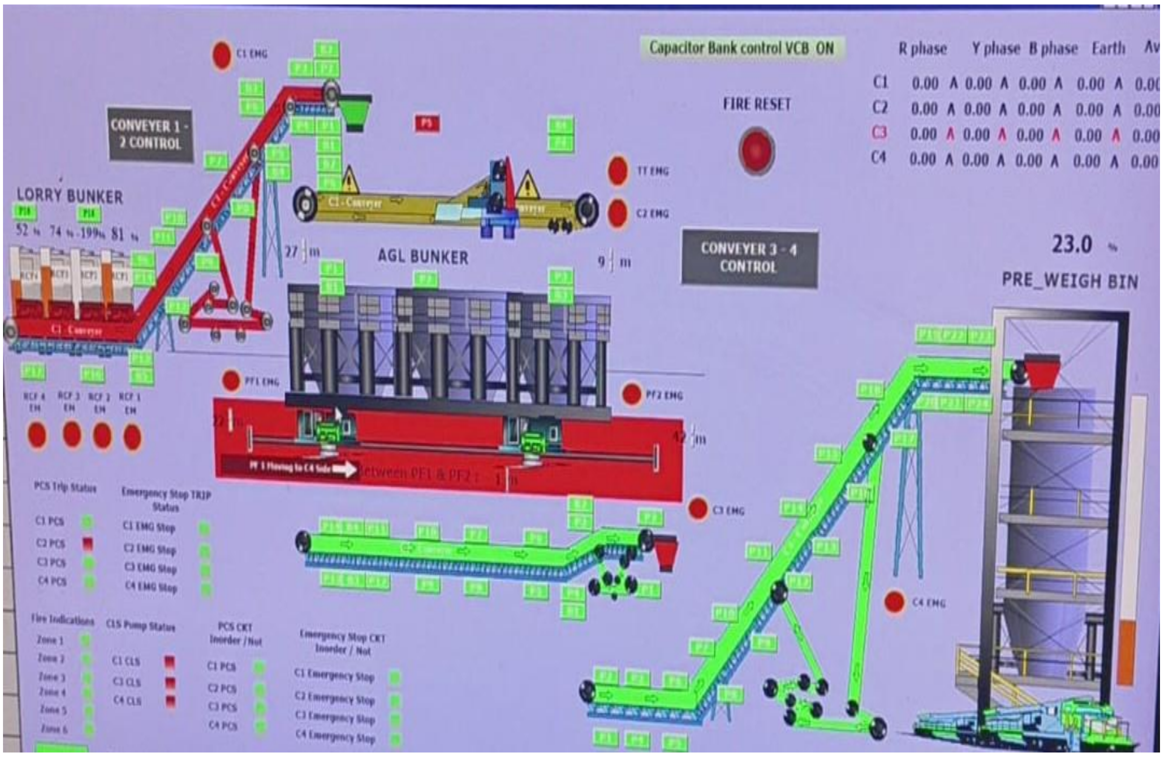


Fig.9.Schematic Diagram of CHP

The image you provided shows a SCADA (Supervisory Control and Data Acquisition) overview screen used for monitoring and controlling a coal handling system (CHP).Here's a brief explanation and operation of the system as shown in the diagram:

5.2 OVERVIEW EXPLANATION

System Title: “Overview” – This is a real-time status display showing different components of the coal handling system.

Software/Integrator: Provided by Consyst (top left corner).

Main Sections Identified:

- Lorry Bunker
- Conveyors
- AGL Bunker
- Pre-Weigh Bin
- Control Panels

5.3 OPERATIONAL FLOW

- Lorry Bunker (Top Left): Coal is dumped from trucks into lorry bunkers.The coal is then transferred onto conveyor belts.Several green-highlighted conveyor belts (showing active/healthy state) transport coal across various points. Each conveyor section is numbered and shows material movement in real time with animated coal balls (black dots).
- AGL Bunker (Center):Acts as an intermediate storage or segregation point.Multiple sections allow different grades/types of coal to be stored separately.Controlled by "Conveyor 2-4 Control" for routing coal to next stage.
- Pre-Weigh Bin (Right Side):Coal is transferred to this bin before being fed into the main plant (e.g., kiln, boiler, etc.).Ensures accurate measurement of coal feed rate.
- Emergency Controls and Status (Left Panel & Top):Emergency Stop, Fire Reset, and capacitor bank status.Power and phase monitoring (top right corner) shows voltage and current per phase.

5.4 COLOR INDICATION

- Green: Normal/Running
- Red: Fire/Emergency feedback
- Grey: Stopped/Idle

5.5 CONTROL FEATURES

The operator uses this interface to:

- Start/stop individual conveyors or bunkers.
- Monitor status of each component.
- Receive alarms for faults like fire, overload, or conveyor trip.

6.CASE STUDY

Coal handling plants (CHPs) are critical components in thermal power plants and industries where coal is a primary fuel source. These plants manage the receipt, storage, transfer, and processing of coal to ensure uninterrupted fuel supply to boilers or furnaces. Due to their complexity and operational hazards, modern CHPs often integrate control and monitoring systems to enhance efficiency, safety, and reliability.

This study focuses on implementing a Smart Control and Monitoring System (SCMS) in a coal handling plant with a capacity of handling 15 million tons of coal annually.

6.1 SYSTEM COMPONENTS

1. Monitoring Sensors

- Temperature and vibration sensors on conveyors, crushers, and motors for equipment health.
- Dust sensors for environmental compliance.
- Load cells on hoppers to monitor coal levels and prevent overloading.
- Gas detectors to identify fire risks or hazardous emissions.

2. Control Systems

- PLC (Programmable Logic Controller) to automate coal flow processes.
- SCADA (Supervisory Control and Data Acquisition) system for real-time visualization, data collection, and control.

3. Communication Network

- IoT-enabled devices and Wi-Fi/LAN ensure seamless data transmission from sensors to the control room.

4. Automation Features

- Automated conveyor belt alignment and speed control based on demand.
- Automatic dust suppression systems using water spray mechanisms.

6.2 CASE INCIDENTS

Here are specific examples of incidents that can occur in a Coal Handling Plant, along with actions and outcomes:

1. Conveyor Belt Fire

- **Incident:** A fire broke out on a conveyor belt due to friction caused by a misaligned belt running at high speed.
- **Action:** Temperature sensors detected the abnormal heat, triggering the fire suppression system. The system sprayed water automatically, and the conveyor operation was shut down.
- **Outcome:** Fire was contained quickly, preventing further damage.

2. Overloading of Coal Hopper

- **Incident:** A coal hopper became overloaded because the conveyor belt feeding it did not stop in time.
- **Action:** The load cell sensor in the hopper detected the overload and sent a signal to the SCADA system to halt the conveyor. Operators redistributed the coal manually.
- **Outcome:** Prevented structural damage to the hopper and avoided system downtime.

3. Dust Explosion Risk

- **Incident:** High coal dust levels were detected in the crushing area during peak operations.
- **Action:** Dust sensors triggered an alert, and automated water spraying systems were activated to suppress the dust. The system also reduced conveyor speed temporarily to control dust dispersion.
- **Outcome:** Risk of a dust explosion was mitigated, and air quality was maintained within safety limits.

7. CONCLUSION AND FUTURE SCOPE

7.1 CONCLUSION

Effective control and monitoring of coal mine operations at the Coal Handling Plant (CHP) are essential for ensuring safe, reliable, and efficient material handling. By integrating automation technologies such as PLC-SCADA systems, real-time sensor networks, and data-driven control strategies, operational efficiency can be significantly improved while minimizing equipment failures and safety risks. Continuous monitoring enables early fault detection, optimized resource utilization, and supports informed decision-making. As coal demand and safety standards evolve, modernizing CHP operations with intelligent control systems is critical for achieving sustainable and high-performance coal handling infrastructure.

7.2 FUTURE SCOPE

Future developments in the control and monitoring of coal mine operations at CHP are likely to focus on automation, real-time sensor integration, and AI-based systems for efficient coal flow management, equipment health monitoring, and hazard detection. Advanced SCADA systems, predictive analytics, and remote control capabilities will enhance operational efficiency, reduce downtime, and improve safety in coal handling processes.

8. ACKNOWLEDGMENT

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