Online Monitoring Software for air Pollutants in Areas near Coal Mines

Shankar S S[1], Senju Thomas Panicker[2], Jerry Daniel J[3]
Control and Instrumentation Group
Centre for Development of Advanced Computing
Thiruvananthapuram, Kerala, India

Tarique Sajjad[4]
Mining Electronics Department.,
Central Mine Planning and Design Institute,
Ranchi, Jharkhand, India

***Abstract*— Coal is the second most source of energy worldwide owing to its easy availability considered to other types of fuels. However, coal mining and its related activities are major sources of environmental pollution. The usage of coal for energy generation adds further to pollution of environment. These activities have impact on both air and water. However, the impact on air due to pollution is more widespread since air pollutants affects a far wider areas around the mines and wind carries these pollutants to even farther distances. Hence it is important to monitor the air pollution in the areas near the mines and take necessary steps to minimize the release of pollutants into the atmosphere. Air pollution mainly consists of gas and particle contaminants that are present in the atmosphere. The major air pollutants produced by opencast mining are suspended particulate matter and respirable particulate matter (PM10 and PM2.5). In addition, mining activities also releases toxic gases like SO2, NOx, ozone, CO, volatile organic compounds (VOCs), and some gaseous forms of metals. In order to keep the coal dust and other gaseous material at safe levels, effective dust control mechanisms are required. Dust Control Systems are an important factor in meeting both environmental and health and safety requirements, helping and protecting employees, and reducing site emissions. Controlling coal dust is vital to worker safety because of the risk of coal dust explosions. This paper showcases an online coal dust monitoring software that monitors the amount of coal dust and other gases at various locations by means of data collected from pollution monitoring devices, maintains a log, and helps in the generation of reports.**

Keywords - OMS; Coal Mine; HMI; GPRS; CDSU;

I. INTRODUCTION

Coal being a primary source of energy plays a vital role in energy-intensive economies such as India. India, as a developing country, lays great emphasis on the production and development of coal in order to fulfill its demand for energy. Coal-fired thermal power plants are key to power production in the country. They play a vital role in power generation and distribution and constitute 64.75% of total power production in India. This has resulted in considerable growth in coal mining in recent decades. Exploration, mining, and benefaction of coal are associated with a variety of environmental hazards. Coal mining, especially opencast mining, has a substantial effect on the environment.

According to the reports issued by the World Health Organization [1] and by environmental groups, coal particulate pollution is estimated to shorten approximately 1,000,000 lives annually worldwide. Air pollution can affect our health in many ways. Numerous scientific studies have linked air pollution to a variety of health problems including (1) aggravation of respiratory and cardiovascular disease; (2) decreased lung function; (3) increased frequency and severity of respiratory symptoms such as difficulty breathing and coughing; (4) increased susceptibility to respiratory infections; (5) effects on the nervous system, including the brain, such as IQ loss and impacts on learning, memory, and behavior; (6) cancer; and (7) premature death. [2]. Some sensitive individuals appear to be at greater risk for air pollution-related health effects, for example, those with pre-existing heart and lung diseases (e.g., heart failure/ischemic heart disease, asthma, emphysema, and chronic bronchitis), diabetics, older adults, and children.

In this paper, we present the Online coal dust Monitoring Software which collects air pollution information from pollution monitoring devices, display them in a graphical format and generates reports on a daily and monthly basis.

II. NEED FOR ONLINE MONITORING SOFTWARE

Mining operation at open-cast mines leads to various air pollutants being released into the atmosphere which affects the environment as well as human health. Transportation of coal from mines to plants is a major source of dust, which not only affects the people working at the mines but also the people living in areas nearby.

This necessitates the monitoring of air quality in the areas near coal mines and take corrective action to minimize the pollution. With this aim, Coal Dust Suppression Units (CDSU) were developed which monitors the amount dust (PM10 & PM2.5) and toxic gases (SO2, NO2, NO and CO) present in the air. The CDSU's activates dust suppression sprinklers when the dust content exceeds safe permissible limits. The pollutant details sensed by the CDSU's needs to be collected for further processing to access the air quality at various areas in and around the mines. In addition, daily and monthly reports of the air quality also need to be generated for further analysis and also for sharing with pollution control boards.

With this aim and Online Monitoring Software was developed that collects the sensor information from the CDSU, process them and generate reports.

III. COAL DUST SUPPRERSSION SYSTEM ARCHITECTURE

The overall architecture of the online Coal Dust Suppression System is shown in Fig. 1. The dust suppression system consists of Coal Dust Suppression Units (CDSU) installed at dust-generating areas in the mines which activates water sprinklers for suppression of dust. CDSU's are devices that are used to

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measure the amount of dust and gas pollutants present in the atmosphere and control the dust by activating water sprinklers. The CDSU comes in two versions – Base and Pro. CDSU Base will sense the amount of particulate matter (PM2.5 and PM10), while CDSU Pro will sense particulate matter as well as SO2, NOx, and CO. The CDSUs are deployed along the road between the open-cast coal mine and the stockyard, which activates dust suppression sprinklers installed along the side of the road when the dust content exceeds a permissible limit. The sprinklers located on the side of the road spray water on the road thus preventing coal-dust from becoming air-borne and also bringing down coal and other dust particles in the air.

In addition to controlling the sprinklers, each CDSU sends the sensed parameters to the Central Server (CS) located at Control Station via GPRS where it is logged for analysis and report generation. This helps in analyzing the coal dust and other gases present in and around the mines keeps track of the amount of water used and also helps in maintaining a report of the same.

IV. Online Monitoring Software

The Online Monitoring Software (OMS) is a standalone server-based application software used for online monitoring of air pollutants in areas in and around coal mines. The basic block diagram of OMS is shown in Fig.2.

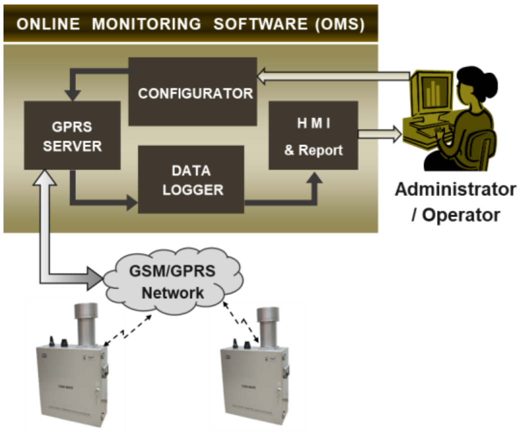

Fig. 2 Block Diagram of OMS

The OMS collects pollution information data from CDSU's deployed in the coal mines using GPRS Server service. The OMS communicates with the CDSU's based on the configuration of the CDSU's entered by the system administrator or operator. This data after processing will then be logged in the database and also sent to the HMI module where all the CDSU parameter values are displayed. The real-time data from the CDSU's will be logged into the database at an interval configured by the user. The OMS software also features a report module which will generate daily and monthly reports of the air quality in the areas where CDSU's are installed.

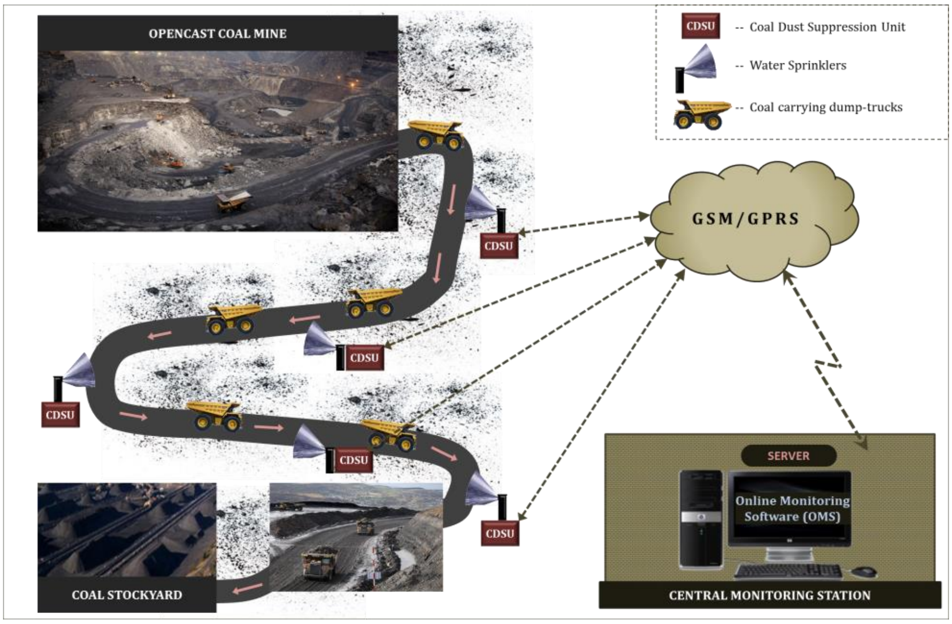

Fig. 1 Overall Architecture of the Coal Dust Suppression System

V. OMS ARCHITECTURE

The OMS architecture is shown in Fig.3.The Online Monitoring Software consists of mainly seven modules.

1. CDSU Configurator
2. OMS Configurator
3. GPRS Server
4. Data Logger
5. HMI
6. Report Generator
7. User Management System

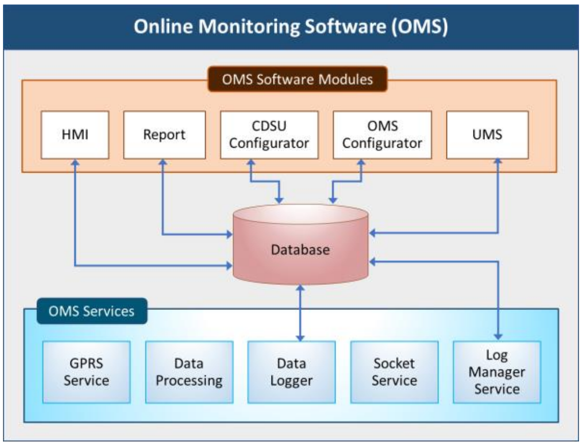

Fig.3 OMS Architecture

The information regarding the CDSU's deployed in the field are entered in the OMS software using the CDSU Configurator module. The sensor information corresponding to each CDSU is then converted as a data tag, in the OMS Configurator module, which is used by the software to identify the sensors values. This tag information is then passed on to the HMI module for online display of pollution parameters and to Data Logger module for storing in database. The Report module access the sensed information (tag values) from the database and generates reports on daily basis based on configuration given in the OMS Configurator module and Report module. Housekeeping of historian database is done through log manage service where the user can configure the period for database backup and delete interval.

GPRS communication service will acquire data from CDSU's based on the CDSU configuration which will be configured using CDSU Configurator. After processing the received data packet the real-time data is then written in shared memory. Based on the OMS configuration, the Socket service and Historian service will read data from the shared memory. HMI will get real time data from Socket service and displayed it in trend. Historian service will log these data to the database with the interval defined by the user. Through Historian interface Report generation tool will collect data from the database based on the tags mentioned in the Report templates.

VI. OMS SOFTWARE MODULES

A. CDSU Configurator

The CDSU Configurator helps to configure the OMS with details of different types of CDSUs deployed at various locations in the mines. The CDSU configurator module provides for adding/mapping CDSUs based on the company to which the coal mine belongs, the name of the coal mine or project name, and the sub-area in the coal mine or project. All these details including the GPRS communication configuration details will be saved in a database and based on this configuration GPRS Server will acquire data from the CDSUs. Fig.4 shows the data flow diagram for the module.

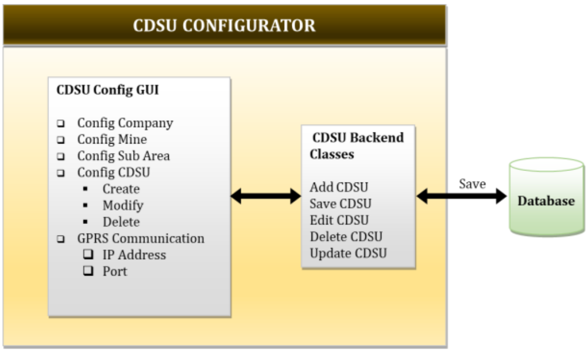

Fig.4. CDSU Configurator block diagram

The entries in the CDSU configurator are arranged in tree structure based on the company name, area name (name of coal mine or project) and the subarea name. The tree structure of CDSU's is given in Fig.5.

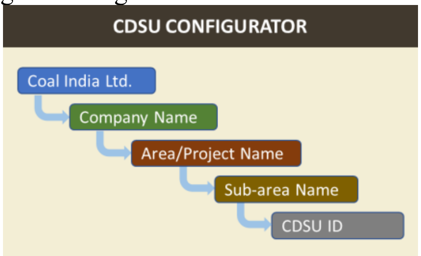

Fig.5 Tree structure in CDSU Configurator

Each CDSU will have a unique identifier based on the company, area, and sub-area name. This ID will be used by the OMS software in order to differentiate between each CDSU's in its list. This ID, which is in addition to the Serial Number of the CDSU's will be used to differentiate between the GPRS packets arriving from each CDSU. Unlike the CDSU Serial Number, which could be any number the manufacturer gives, the CDSU_ID is auto-generated based on the code for the company name, area and sub-area.

B. OMS Configurator

OMS Configurator module is used to configure the sensor tag information of each CDSU such as a tag that can be configured as a Historian Tag for logging. Three types of logging can be configured: - Periodic, Log on change, and Schedule Logging Tag.

Each of the CDSU is mapped with the respective Data Source. Data Sources are automatically created when a CDSU is configured in CDSU Configurator. On deletion of a CDSU from Configurator, the corresponding Data Source also will get deleted.

Units corresponding to each sensor tag in the CDSU are automatically created when the CDSU is configured. This can be modified to user preferred format in the OMS Configurator. Database restoration and deletions activities of the OMS software can also be performed using this module.

C. GPRS Server

GPRS Server, which runs as a Windows service, is the data acquisition module of the OMS software. The GPRS Server manages a TCP/IP server socket to which all the CDSU's

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connect as client units [3]. After establishing a socket connection with a CDSU, the GPRS Server starts acquiring data from the CDSU. This data is then processed and sensor information is extracted based on the configuration provided in the CDSU Configurator. The sensor information is then mapped onto a data tag and is then passed to HMI and Data Logger for display and logging respectively. The received data after processing is written into shared memory [4][5] from where socket service will read and display it in HMI and log the data in a database based on the historian configuration. The block diagram of the GPRS Server service is shown in Fig.6.

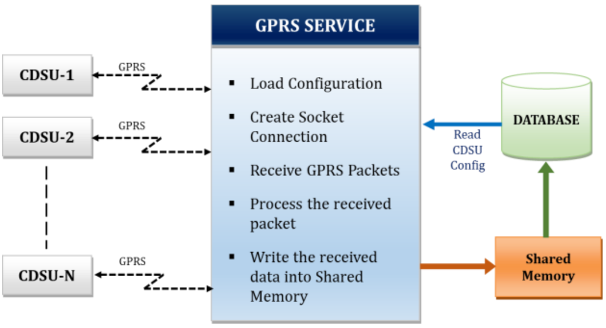

Fig.6 GPRS Server block diagram

D. *Data Logger*

The Data Logger module provides logging and playback facility for the OMS. The Data Logger module logs the real-time data sent by the CDSU's into a database and retrieves it for report generation and display of historic trend on HMI. Logging shall be done based on a time or based on change in the measured value, as configured in the OMS Configurator. It will also run as a windows service application. Fig.7 shows the block diagram of the data logger module

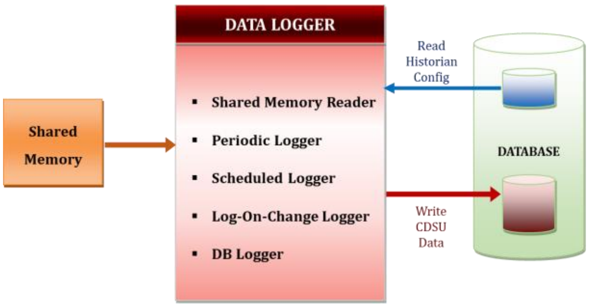

Fig.7 Data Logger block diagram

E. *HMI*

The Human Machine Interface (HMI) module [6] provides a visual display of the parameters being monitored in the coal mine area in the form of dials, bar chart, or as value display. The HMI shall also provide a graphical display of the parameters in the form of online/historic trends.

The HMI module has the provision for generating HMI frames based on user preference using various components like text boxes, value components, dials, bar charts, etc. The generated HMI frames are also stored in the database and is retrieved for display when it is required by the user. Fig.8 shows the block diagram for HMI.

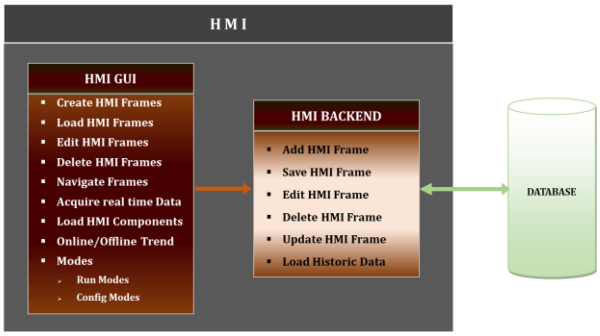

Fig.8 HMI block diagram

The OMS has a Historian [7] interface which communicates between HMI and the historic database for showing a historic trend. The Trend submodule of HMI also has the provision to interact with this module for loading Historic Data into the Trend. Report Module has the provision to interact with the historian interface for loading historic data into the Report template. Fig.9 shows the block diagram of the Historian Module

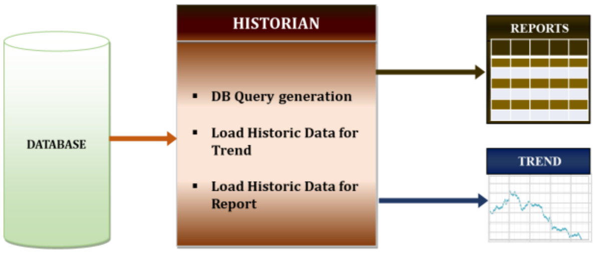

Fig.9 Historian block diagram

F. *Report Generator*

The Report Generator module of OMS provides for generating reports of the data collected from various CDSU's. It also has a provision to create and save report templates based on user preference. It also has the provision to generate automatic and manual reports. The automatic reports can be generated on a daily or monthly basis. The generated reports can be exported or downloaded in PDF or Excel format. Fig.10 shows the block diagram of report module.

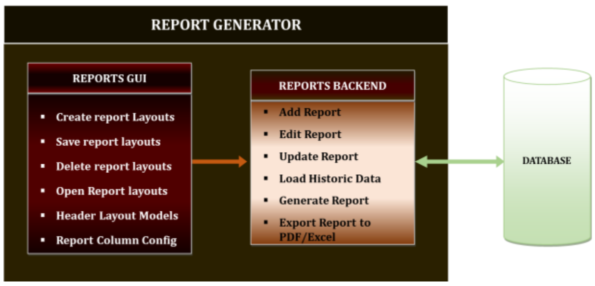

Fig.10 Report module block diagram

G. *User Management System*

OMS has user authentication in the form of a username and password, which can be entered from the OMS Home page is shown in Fig.11. The OMS features a User Management System which provides for creating and editing users and assigning privileges. User details such as User name, ID, designation, and Photo can be added. UMS helps to configure User Groups, Applications, Privileges. Users which are newly created can be assigned to a group with either administrative privileges or operator (limited) privileges.

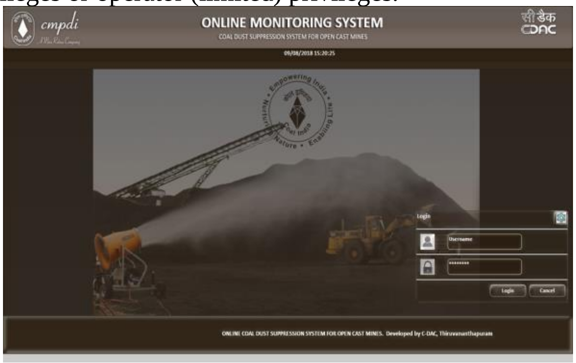

Fig. 11. OMS Home page

VII. RESULTS

The developed system was implemented at Asoka Opencast Mine in Jharkhand, India. The CDSS system consist of 13 CDSU Base units and 2 CDSU Pro units
deployed at various locations in the mines area. This is configured in the CDSU Configurator module of OMS based on the location where each CDSU is installed, as shown in Fig.12. The CDSU units measure the concentration of PM10, PM2.5, SO2, NO2, NO and CO in the respective areas and forwards them to OMS software using GPRS mode of communication. The OMS software collects the data from the CDSUs and generate report to assess the air quality at these locations. The pollution information is also displayed on the HMI for real-time viewing of the pollution status in these areas, as shown in Fig.13. An HMI frame has also been created which displays the status of the dust suppression sprinklers and level of water in the water tanks, as shown in Fig. 14.

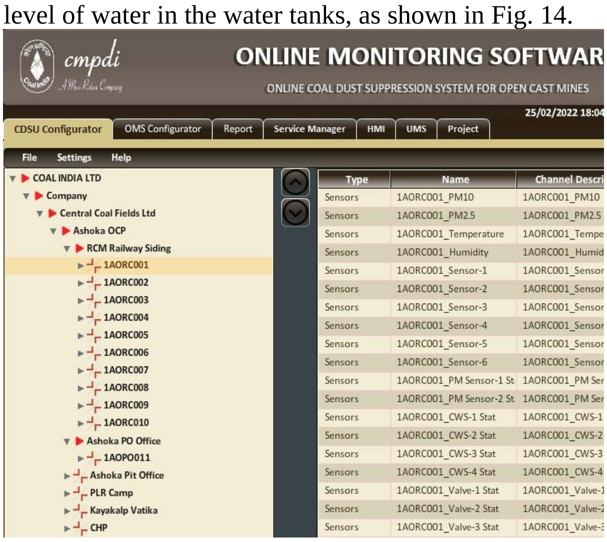

Fig.12. CDSU's configured in CDSU Configurator

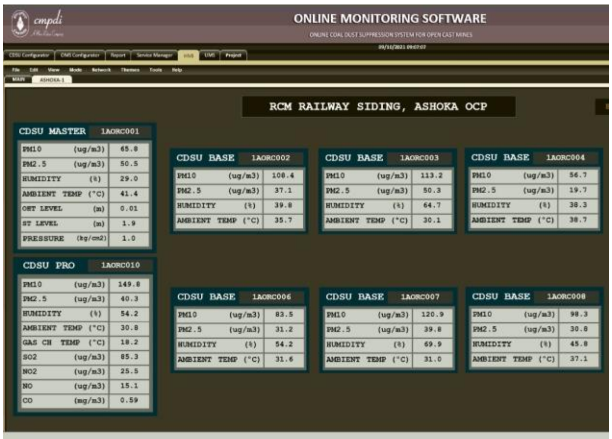

Fig.13. HMI Frame showing pollution data at various locations

Fig.14. HMI Frame showing sprinkler status

VIII. CONCLUSION

In this paper, we have presented the development and implementation of an online coal dust monitoring software for monitoring dust and gas pollutants using CDSU controllers. The system will acquire the amount of PM_{10}, $PM_{2.5}$, SO_2, NO_2, NO, CO present in the air through GPRS communication. These values will be displayed in HMI and thereby informing the plant officials about the quality of the air in the coalfield.

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