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Ventilation of Coal Mine Methane Using Wireless Sensor Network

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Abstract*—.The steady rise in gas fatality and the health problems faced by the miners of the underground mines have been a major issue of concern to the field of mining. The unpredictable behavior of gases inside the mines has led to death of many in the recent times. The main reason for increase in mine gas fatality rate is Fire damp in which main constituent is Methane gas. Leakage of methane gas leads to explosion in underground mine. This paper discuss about exhaust of leaked methane gas in underground mines. The concept of wireless sensor network used here is to get data about different level of methane gas in underground mines. Sensors are deployed in various places to sense the increase of methane gas. When the methane reaches the level enough (5-9.8%) to cause fire damp, they will initiate the automated alarm system to alert the workers about increase in level of fatal gases which will further initiate the ventilation system to dilute the air inside mine in order to minimize the chances of fire damp. The air inside the mines is being drained out through pipes which can be either stored in large container for further use or simply drained out into the atmosphere. The ventilation system which is being operated automatically which is initiated by the sensors.

***Keywords*—Coal mine methane ventilation, Wireless sensor network.**

I. INTRODUCTION

The importance of Mining in the growth of economy for any developed or developing country is a very important aspect. Ores recovered by mining includes minerals like iron, mica, manganese etc. The ores also consist of oil, metals, gemstones, coal etc. These minerals and geological materials extracted by mining have a direct effect on the growth of the country as these minerals provide the basic raw material to any heavy industry. Thus the enormous importance mining has led to an exponential rise of mining since a very long time. The types of mining can be divided into two major techniques; they are surface mining and underground mining respectively. The surface mining deals with stripping down the vegetation, dust and often the layers of bedrock of the earth to reach the deposited ore, whereas the underground mining deals with tunneling the way to reach the deposited ores. The surface mining is comparatively safe than underground mining. The fatality rate in the underground mining has been alarming. Some of the major accidents in the underground mining are due to the falling of roof, fall of side, the Damps such as fire damps, black damp, white damp etc. This paper discuss about leakage of methane gas in underground mines and its ventilation so as to avoid accidents like causing explosion, suffocation which increases fatality rate. The level of methane gas is measured by methane sensors. These sensors are attached to a wireless sensor node. These nodes are deployed at different location inside the mine. This node transmits the data or the level of the methane gas inside the mine tunnel to the control room from where it can be monitored. Automated alarm system is initiated when the level of gas reaches the danger level. To ensure the safety this process further initiate automated ventilation system which drains out the gas out of the mine for storage or utility purpose?

II. MINE GASES

The gases most commonly found in mines are oxygen, nitrogen, carbon dioxide, carbon monoxide and methane. The most commonly found toxic gases are carbon monoxide and methane in which carbon monoxide is due to explosion, gob fires and blasting operations where methane gas comprises 97% of toxic gases. Methane gas is the chief inflammable constituent of fire damp which is nearly 70 – 98% besides other gases like ethane, propane, ethylene, acetylene, hydrogen sulphide. Fire damp actually given off by coal or other strata has a composition lying between the following approximate limits.

Table.1. ABOVE table shows gases and its amount under mines

Methane	70 to 98%
Ethane, Propane	0 to 2%
Ethylene, acetylene, hydrogen sulphide	0 to a trace
Carbon dioxide	0 to 4%
Nitrogen	0 to 15%
Oxygen	0 to a trace

Among these gases depicted in the above table methane, propane, ethane, ethylene, acetylene, hydrogen sulphide are inflammable gases whereas oxygen, nitrogen and carbon dioxide are flammable gases.

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III. COAL MINE METHANE

Coal Mine Methane is the methane recovered when coal is in the process of being extracted. Methane (CH_4) is a natural gas given off by coal and carbonaceous strata in coal mines or it may occur under great pressure in porous rocks adjacent to a coal seam where it has been imprisoned by an overlying bed of non-porous rock. It is generally formed during coal formation i.e.; coalification. Methane is released due to extraction of coal by various modern techniques like longwall mining and other sub-surface techniques. It is released due to seepages, blowers or feeders, outbursts. Seepages generally referred to steady oozing out of gas from coal seam through tiny pores. Blowers or feeders is the release of the gas with a hissing sound causing a great accumulation. Outbursts occurs where coal is being worked out in the mine containing gas under enormous pressure. These causes increase in fatality rate under the mines. Methane is an inflammable gas and when mixed with a certain proportion of gases form an easily explosive material. Any mixture of air containing methane between 5 and 14.8% is explosive in nature which are normally prevailed in mines. This range is called explosive range of methane and air. The lower limit of inflammability of methane gas in still air is 5%. Below this level methane is too weak to cause an explosion but burns around the source of ignition forming a secondary flame i.e.; coloured pale blue cap. The most violent level of explosion occurs at a level of 9.4% of methane in air. The safe situation under the mines when theBelow this level mixture of methane and air does not causes any harm under mines.

IV. WIRELESS SENSOR NETWORK

Wireless sensor network (WSN) consists of small nodes with sensing, computation, and wireless communications capabilities. A WSN consists of sensor nodes deployed over a geographical area for monitoring physical phenomena like temperature, humidity, vibrations, seismic events, and so on. In this paper the nodes are deployed under the mining tunnel. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. Fig.1. shows the basic architecture of a WSN node.

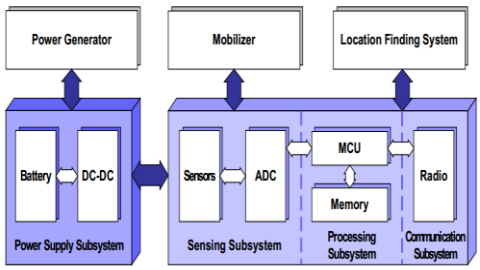

Fig.1. Architecture of typical wireless sensor node

The power system subsystem in the node shown in fig.1 consists of the power supply unit of the node which is a 12V DC supply battery. The DC- DC converter in the subsystem helps in reducing the noise of the supply and also to step down the supply voltage to the optimum supply voltage of sensor and microcontroller. The sensing subsystem consists of the methane level sensor and the ADC (Analog to Digital Converter). The Methane sensor is a device used for measuring the proportion of methane in the given environment. The sensor measure the concentration in ppm which is then converted to electrical signal which is stable and reliable and can be fed to any measuring instrument or controller .This ADC converter converts the analog data of the sensor to digital form which is understood by the microcontroller. The microcontroller is the major part of the node which takes the sensor output as input, store the data in the memory and also send the data to the control room with the help of communication subsystem. The communication module is responsible for transferring and receiving data from other nodes. The communication subsystem consists of radio module, which is generally a radio frequency modem. Zigbee is one of the kind of RF modem which is a high level communication protocol used to create a Personal Area Network (PAN). It follows IEEE 802.15 Standard. The data of each WSN node is transferred to gateway sensor node whichcollects all the data from different nodes and sends them to the control room. The gateway sensor node of the WSN is associated with the SCADA (Supervisory Control and Data Acquisition) system in the control room on the surface. The sensors nodes deployed far from the reach from the receiving range of the centralized node send their data to the gateway sensor node through a technique called Multi hopping. In this technique the node sends its data to the nearest neighboring node, which then sends this data to the next neighbor and so on till it reaches to the gateway sensor node. Fig.2 explains the multi hopping technique.

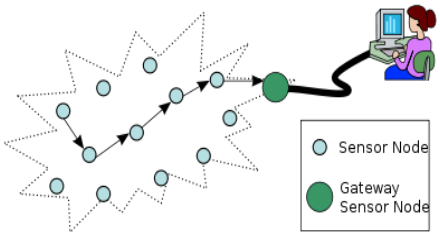

Fig.2. Multi hopping techniques in wireless sensor network

V. METHODOLOGY

The flow chart of the methodology is depicted in fig 3. The system described in the paper consists of the methane sensor which provides the necessary data to realize the proportion of methane inside the mine. The data then is gathered in the particular node associated with the respective sensor. This node stores the data till the next data is sensed. The data of each node is acknowledged at a certain time delay to avoid collision of data from

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different nodes, this is called periodical data. The node then transmits the data to gateway sensor node which is also a centralized node which collects all data from the nodes. The data from the node then is send to the control room which consists of the SCADA. The SCADA then compares the data received with the predefined data assigned to it. When the methane level exceeds 1% i.e.; above the safety level, the sensors senses the rise of the level and automatically activate the large ventilation system which exhaust out the inflammable gas mixture and pump in the outside air hence diluting the concentrating the air inside the mine bringing the methane level under 1%. Sometime methane are released from high compressed gas which causes increase in methane above at a high speed. When the level of methane exceeds 3% , the ventilation system activate the automated alarm system alerting the increase of gas so that cautious measures can be taken by the workers inside the mines.

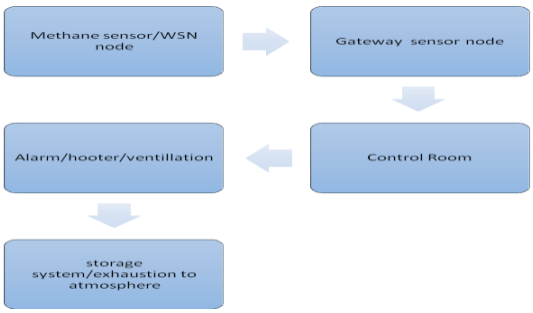

Fig.3. Flow chart of the system

VI. CONCLUSION

The paper has discussed about the problem of raising the level of methane and necessary action to be taken by ventilated system. The methane collected by the ventilated system are stored in large tanks in an isolated area which can be used further for energy purpose like biogas or electricity production purpose. These automated ventilation system can reduce fatality rate under mines and also can reduce manual task of regulations of ventilation system. These sensors also regulate automated alarm system to alert workers about rise of fatal gases inside the mines.

REFERENCES

[1] Somov, Andrey, et al. "Development of wireless sensor network for combustible gas monitoring." Sensors and Actuators A: Physical 171.2 (2011): 398-405.

[2] Anastasi, G., Conti, M., Di Francesco, M., &Passarella, A. (2009). Energy conservation in wireless sensor networks: A survey. Ad Hoc Networks, 7(3), 537-568.

[3] Dange, Mr Kumar agar M., and R. T. Patil. "Design of Monitoring System for Coal Mine Safety Based on MSP430.

[4] Design of a methane monitoring system based onwireless sensor networks by Abdullah ErdalTümer and MesutGündüz.

[5] About coal mine methane from www.worldcoal.org.