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A novel approach for disaster prevention inside underground mines

Industrial safety measures and protection is the most imperative division of any industry. Safekeeping in the ordinary industry, commercial places and underground mines are different, as underground mine atmosphere is more multifaceted in environment. Mine calamity is extremely hazardous as it may influence the nearby region outside mine area. Mine accidents may have long term impact on the surrounding locality. Disaster inside underground mines has a large number of past examples. This research article gives a scheme associated with the safety and security of mine personnel as well as costly equipment inside mines. This article describes the measurement of valuable parameters, their analysis, monitoring to shun probable calamity inside underground mines, as well as other places with essential modifications. The proposed system is cost effective and reliable. The data management software designed here keeps record of all the necessary parameters.

Keywords: *Industry; underground mine; wireless communication; wireless sensor network; Zigbee; disaster management; security; cost-effective.*

I. Introduction

Security, safety of any personnel inside the working situation is almost important. In any industry large number of costly, essential types of equipment are there to guide the industry. To protect human life as easily as a wealth of the governing body is necessary for the brand name of the society. To avoid failure of running industrial process, proper safety and security monitoring devices must be installed in each industry. As human culture has progressed demand for metals, energy increases. As demand increases production also increases to match the increase demands. More number of new mines come into operation. Update information inside the working place like underground mines to the base station improves the productivity as well as the refuge of the underground working personnels. Disasters inside mines have many instances. Mine disaster occurred, underground power and communications systems were severely damaged, and cause great difficulties for the relief effort [1]. In some cases working personnels often trapped in underground mines. Many numbers of this type of examples are in that position. Carelessness, casualness concerning the protection, precautions concerns may lead to failure, detrimental of high excellence, costly equipment, which will hamper, total shut down of production of a particular unit or may cause risk to human life in some extreme cases. Disaster management system includes two types of operation – pre-disaster warning system and post disaster warning system. Post-disaster management system faces problems with lack of information i.e. amount of damage occurred. The rapid and efficient disaster management is critical for reducing the negative effects by the disasters [2]. During underground mining operation due to roof fall, heavy explosion, sometimes people trapped in the domain of the underground mine. Only a small amount of energy is required to ignite an explosive mixture of methane and air [3]. Prediction of possible disaster is the most important part in any disaster management system. The expanse and complexity of disaster response and recovery is staggering, requiring a wide range of resources to ensure the safety of the population and the recovery of the affected area [4]. Mine disaster can happen in several ways. Nature of mine disaster varies from mine to mine based on the end product as easily as its geographical locations. For instance, coal mine disaster is really serious. After a disaster if workers trapped in mine which is full of different chemicals, our first aim should be to make them positive. But the rescue team must be aware of the tunnels. In mines where bulk bodies of ore are found, the mining technique generally involves the development of an underground cavity that is produced by blasting and excavation [5]. The quick response team must be aware of the geographical condition of the underground mines.

II. Types of mine disaster

Disaster inside underground mines can generate enormous devastation. Leakage of harmful gases is dangerous for both the working people as well as surrounding domestic peoples. For example, methane gas concentration is a vital problem in

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mining industry. Methane liberated in coal mines is a potential safety hazard, because it is explosive at relatively low concentrations (5%-15%) in air [6]. Detection of the source of leakage and type of gas is most vital. Elimination of the affected area may render a result. Escape of gas may also lead to burst within the main district. Coal dust and some gases may generate explosion in the domain of mines. The mining industry requires a reliable system to accurately and safely measure methane concentrations at various locations in underground coal mines [7]. A little spark can ignite explosive gases, which may lead to multiple explosion. Due to leakage of chemicals surrounding water may contaminate. Agricultural, cultivated land may be polluted with poisonous chemicals. These characters should also be taken care of. One major trouble inside mines is the roof falling problem. Sudden roof fall may lead to problem in the production of the industry. Due to this incident people inside underground mines may be entrapped inside the mine field. Sudden roof fall is detrimental inside the underground mines. Underground may sometimes face damages due to water seepage problem; in underground mine water influx may take shape into huge amount. These flooding may lead to loss of property as well as may contribute to loss of human spirit. Due to seepage problem construction may weaken. This may lead to roof fall in time to come. Due to complex environment of the coal mine, it is necessary to monitor the information of underground environment, device and miner instantly in order to ensure the safety of coal mine production [8]. Our aim is to design a reliable faithful disaster management system inside underground mines. Other cases of accidents include electric shock, transportation accident, etc.

III. Proposed disaster management model

In the previous part we discussed some different cases of accidents which may occur in underground mines. Disaster management system can be split into two parts – pre-disaster management, post-disaster management. From a technological point of view the base station should continue as a track about total no. of employees operating in underground mines. Information about different parameters inside underground mines is necessary in society to take necessary important decision. Coal mine safety management is one of the most important basic criterion, and related to almost all coal production systems [9].

Sensor technology can take on an important role inside underground mines. We can practice different types of sensors to monitor different useful parameters inside underground mines. Dissimilar types of detectors are available. For instance we can employ a detector which can evaluate the absorption of sugar DI oxide SO_2 gas in the confined surroundings. If absorption of that particular gas exceeds a threshold limit a particular alarm sound, for example siren sound will be engendered. The generated alarm sound is a message to the working people of that country about possible threats. This message must be passed to the base station for further processing. If the absorption of carbon monoxide, CO gas exceeds a threshold value beep sound will be engendered. This message should be apportioned by the working people in that country as easily as to the base station for their data. This multi sensor based technology is really helpful to engender the idea about the environmental condition inside underground mines. Sensor networks consist of a large number of inexpensive wireless devices densely distributed over the region of interest [10]. The purpose of a good, faithful communication system must be there. This scheme uses different types of sensors like monitoring of acetylene gas, monitoring of coal dust, fume sensor, fire alert, etc. Underground mines communication system is very defective. The wired communication system is not efficient as it may not be efficient in places like a roof falling, claps etc. Pre-disaster management includes information collection, processing warning, etc. Effective pre-disaster warning system is very much efficient as it gives the opportunity to the workers for evacuation. But the post disaster management system is crucial. Time here is a very vital component. Suppose some workers trapped in underground, our aim will be to rescue them as early as possible. The communication here plays a vital function. Wired communication inside mines is costly. Initialization, maintenance cost is high. The most disadvantages part of this type of communication system is that during a most crucial spot, i.e. fire, roof fall, collapse, explosion it may not work. We cannot bank on this character of network as this type of network may no longer work during most urgent post-disaster condition.

The management should divide the playing area into some zones like zone 1, zone 2, zone 3, etc., for better monitoring of the operating environment as indicated in Fig.1. The management should receive a clear geographical map of the underground tunnel. If any disaster occurs at whatever time the evacuation process should be found on the geographical map of the underground tunnel. The base station should transmit with the working people of each zone. Monitoring of different useful parameters of each zone of the home station is necessary. We use Zigbee based wireless sensor network system for this determination. Sensor networks are usually

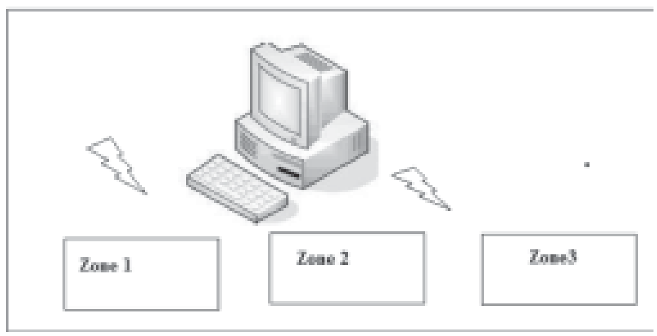

Fig.1 Communication system of the underground mines parameter monitoring system

deployed in a sensing field to collect useful information from it [11]. Wireless sensor network based systems hold an important role in this type of situations. We can use Zigbee technology for the transmission of data from underground tunnel to the base station. Zigbee consumes less power, a very much economical way for the transmittance of data from one lieu to some other. Zigbee is a worldwide standard of wireless personal area network targeted to low-power, cost-effective, reliable, and scalable products and application [12].

In Fig.2 the circle represents each node of the mesh. This network topology can be utilized in underground mines for monitoring different environmental related useful parameters. Zigbee based systems are nowadays very popular in industrial applications. The popularity of Zigbee devices continues to grow in home automation, transportation, traffic management, and industrial control system (ICS) applications given their low-cost and low-power [13].

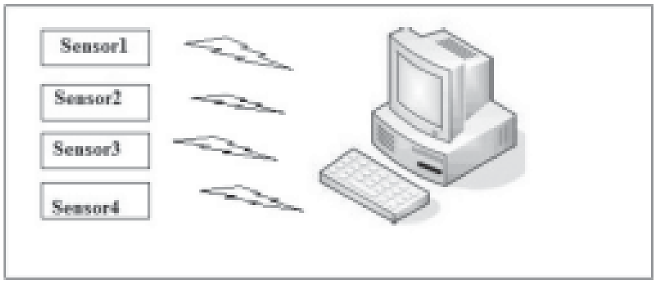

Fig.2 Collection of data from different sensors in a zone

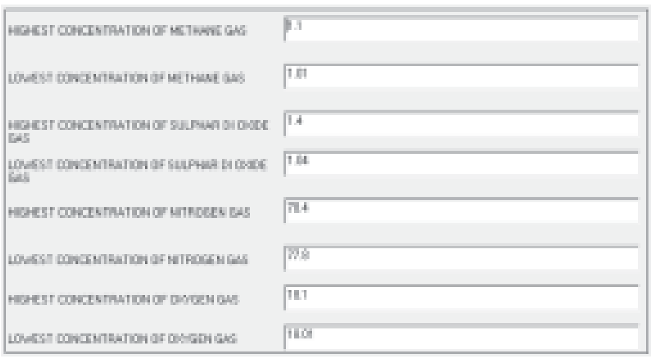

Fig.3 An example of some sample data inside underground mines of a particular zone

Global software development is a major trend in software engineering [14]. Data management software was planned keeping in mind the above discussed issues. In this software the manager can keep a track of the total number of employees operating in a special zone on a particular switch. This information is very essential for safety point of view. Disaster can happen inside underground mines. If due to roof fall or any other disaster some workers trapped inside underground mines, the concerned authority should know how much workers are there inside underground mines in a particular zone. This information should be shared with the quick response team for the survival of the workers. The software also makes a record of different useful parameters like concentration of different gases present in the mining environment. This information can be used to prevent disaster inside the underground mines. If the manager who is preferably sitting at the base station finds any abnormality in the working environment he should take necessary action. There must be a voice transmission system installed between inside underground mines workers and the base station manager. The manager will keep in touch with the underground mine workers for sharing information regarding production, safety etc. The data management software will keep the record of all the necessary parameters throughout the year. These data will be used in future to take decision about previous history. Analysis of these data and comparing with it with the previous historical data stored in data base helps the industry to avoid any disaster. For example if concentration of a particular gas increases by a certain percentage, it may create problem. If the manager any time finds that the concentration of a particular gas increases, which may create problem proper precaution must be taken immediately. Proper ventilation strategy, functioning of extra exhaust fan, mixing of more normal air can reduce the concentration of that particular gas. The best use can be made of the data if we can find from them the most probable frequency or occurrence of any observed magnitude of the physical quantity or, in other words, the most probable law of distribution [15].

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