An Instinctive Detection and Communication System for Plummeting Accidents Due to Methane Explosions in Coal Mines

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ABSTRACT:

The research work described and presented in this paper is mainly aimed at providing an effective means of detecting methane releases which when reaches explosion limit can result in explosions and can cause huge damages not just to the coal mine infrastructure but also to the miners and can affect the surroundings as well if we brief up some of the damages due to methane explosions. The research work also focuses on providing a communication system capable of transmitting information collected from the miner's detection sensor to the outside monitoring and/or safety departments in case of an emergency situation due to the methane releases. The research uses the wireless communication obtained through the use of the Zigbee communication and IoT techniques.

Keywords: Methane explosions; miner's safety; coal mine safety; Zigbee communication; IoT; wireless communication.

I. INTRODUCTION:

Formulating the various causes of methane leakages, the shortcomings of the existing safety systems like lack of flexibility and inadequate safety needs etc., [1] [2] and the effects of methane [3] [4] [5] is the basis on which the research work is built upon. Understanding the above said factors gives a clear picture of what additional is required to be done in order to reduce the misfortunes due to the methane leakages related accidents. Moreover, the research work is also based on the ground work related to getting knowledge about the possible areas in the coal mines where methane gets accumulated and the possibilities and scenarios where methane can mix with the air and fall into the explosion range which can possibly trigger a methane explosion in the coal mine [6]. The severity of the accidents due to methane explosions is one among the biggest concerns for the global coal industry, worker safety unions, national safety organizations and other such organizations linked to ensuring safety at the coal mines.

The use of coal is well known as one of the valuable and major energy resources for many of the developing and industrialized countries. The coal dependence in different kinds of industries such as the cement manufacturing, steel industries, liquid fuel production and electricity generation etc., requires the need to protect this valuable asset which is available in abundant quantity to continue the benefits from its use. This huge and continued demand on the production of coal has pulled a trigger to produce coal in large quantities which sometimes comes up with compromising the safety at the work place in the coal mines.

There have been many accidents noted in the recent past due to methane explosions which includes the methane explosion occurred in the Ruda Soska, Poland which killed 23 miners and the mine explosion

in Russia (Ulyanovskaya mine catastrophe) which resulted in death of 106 people [7]. The severity of the accidents and the damages thereafter the methane explosions raise an alarm to develop an efficient and reliable system to detect the methane leakages and communicate the information to the monitoring station so as to avoid the methane explosions and settle the methane quickly not allowing it to stay in the explosive range. This is driving force for the research work. Apart from detecting the methane and communicating the alarming signal to the monitoring station located around the World (accessible through Internet), the research also provides a means to detect the presence of the miner in case of a methane emergency situation which helps the rescue team to rush to the particular place without taking much time.

II. APPROACH OF THE RESEARCH WORK

The research work is built around carrying out the below mentioned tasks. It is based on ensuring the reduction of the coal mine accidents and damages both to property and miner's lives due to the explosions resulting from methane leakages [8].

- Detecting methane
- Triggering an alarm in the coal mine environment when methane reaches the threshold.
- Communicating the data to the monitoring station.
- Checking the presence of the miner's in the methane effected area, if miner's are found then updating the monitoring stations and the rescue team to rush to the place.

III. BLOCK DIAGRAM AND WORKING

The complete design of the proposed research work is briefly explained here with the help of the block diagrams shown in the below figures (1) and (2) describing the complete system and the methane detection system respectively. The below figure (1) shows the connections between the methane sensor & logic circuit, Ethernet & Wi – Fi circuit and the Zigbee transceivers connected to perform the methane detection and communication system to reduce the possible damages due to methane explosions.

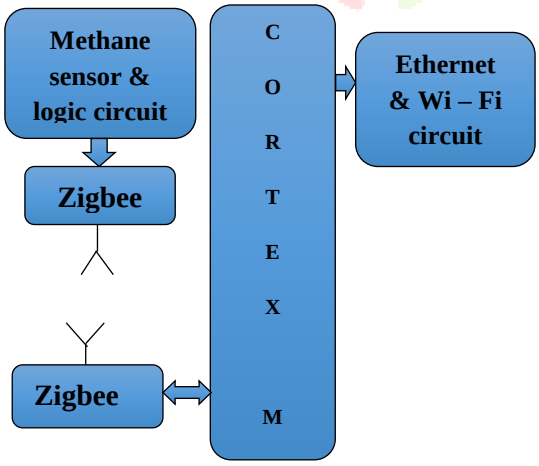

Figure (1) Complete system design

The research work uses a methane sensor with the control circuit with the help of which the user can adjust the level of methane to be considered as the threshold reaching which an alarm will be triggered and

threat warning will be sent to the monitoring station, safety department, rescue department etc., wirelessly with the help of the Zigbee communication and IoT.

In addition to methane gas being prone to resulting in explosions, its nature as one of the potent GHG makes it a topic of concern to be dealt with an efficient way to overcome the losses due its explosion or GHG nature.

The methane sensor & logic circuit contains a transistorized logic circuit containing a potentiometer which allows the user to set the threshold limit of methane detection which is usually set considering the explosion behaviour of methane when it reaches the explosion range which is between 5% to 15%. The level of methane is dropped down to zero very quickly with the help of the proper ventilation systems in the normal workings. But in the case of a ventilation system failure or a sluggish ventilator which does not cover all the areas in the coal mine, there can result places where methane does not get dropped down to zero quickly instead it stays; in the worst scenario when it stays in the explosive range any ignition source can trigger an explosion resulting in huge losses as fire spreads rapidly in the coal mine unless stopped by any of the fire prevention methods. The data from the methane sensor control circuit is connected to the controller which takes decisions based on the program stored in the controller's memory. The main processor which is the brain of the research work and takes data from the various methane sensor nodes through Zigbee communication is based on the Cortex M3 processer. The presence of the miners in the case of an emergency situation is obtained from the PIR sensor module which detects the live beings. The data reaches the monitoring station through the Ethernet controller and the Wi – Fi router.

The research work carries out the task of detecting the level of methane which would help the monitoring, safety and/or rescue teams to ensure that methane explosions are avoided and the buzzer alarm will guide the miners to evacuate that particular place and escape through the escape routes formed in the mine.

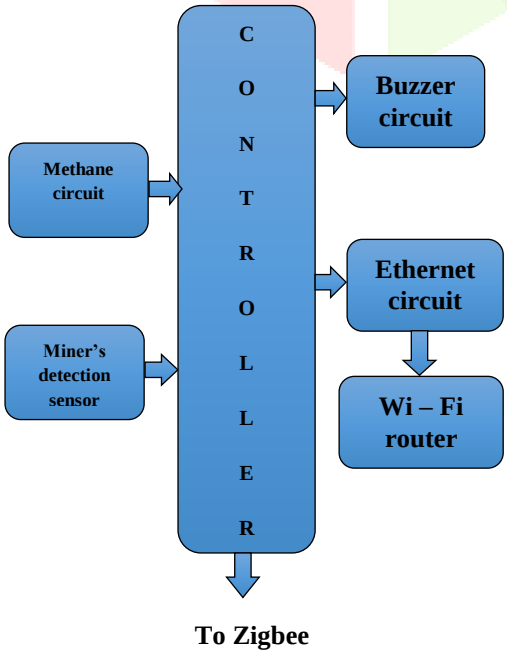

Figure (2). Methane sensor circuit

IV. RESULTS AND DISCUSSIONS

The past history of the accidents (both fatal and non – fatal) and the shortcomings of the existing coal mines which has been stated in the above sections based on literature survey carried out based on the past research activities was the driving force for this research work. The results obtained showed that the safety performances in the underground coal mines can be improved and accidents and the damages because of the methane explosion accidents can be reduced with the help of the proposed research work. The below graph in figure (3) shows the methane sensor module readings obtained in the normal and emergency situations.

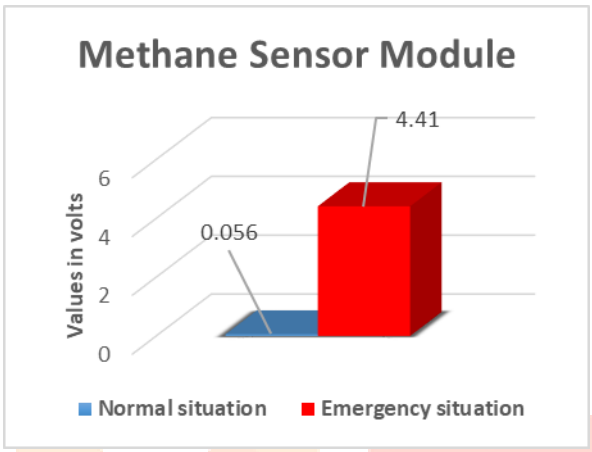

Figure (3) Methane module readings

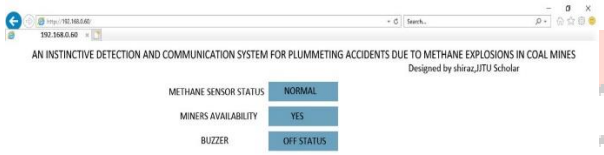

Figure (4) Normal Condition

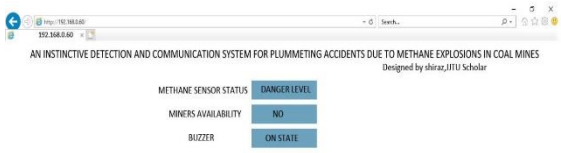

Figure (5) Emergency situation (no miners)

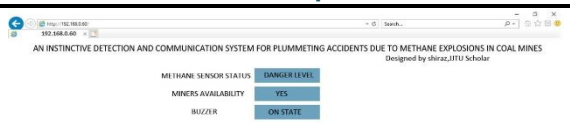

Figure (6) Emergency situation (miners present)

The screenshots of the outputs are shown in the above figures (4), (5) and (6) showing the status of the methane sensor, miner's detection sensor and the buzzer.

V. CONCLUSION

The research is targeted on contributing in the noble cause of providing safety to the miners and in increasing the revenue generated from the Coal industry which plays a role in developing the nation and satisfying and meeting few of the very important needs; electricity, cement, steel etc. The work is will play a key role in ensuring safety in the coal mines if the implementation is done following all the safety procedures and evaluating the past history of accidents and the nearby atmospheric conditions and the industries.

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