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# Developing an Enhanced Safety System for Averting Accidents Due to Spontaneous Combustion of Coal

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***Abstract***

***The research work described and proposed in this paper basically aims at improving the coal mine (CM) safety against the accidents which can arise due to Spontaneous Combustion of Coal (SCC). The research work proposes the detection of $CO_2$and temperature at multiple points in the CM and communication of the data received from multiple detection points to the monitoring station with the help of the cutting edge communication techniques viz., Zigbee and internet communication. The concept of repeating the Zigbee modules after certain distances forming a multiple hop communication increases the transmission range between the sensors location and the internet communication sub – module. The research work also involves the use of the enhanced cooling mechanism to cool down the coal which are heated due to spontaneous heating. The internet communication (IoT) in the proposed work is realized with the help of the Ethernet controller and Wi – Fi router which transfers the data wirelessly to the monitoring stations situated around the world (provided internet connection exist). In the event of the failure of internet connection, the proposed work establishes the communication of sensors data from the underground CM environment to the nearby monitoring and rescue departments with the help of the Wi – Fi communication. The research work will have a great impact on reducing the accidents due to SCC.***

***Keywords: Spontaneous heating of coal; Zigbee; IoT; Ethernet controller; $CO_2$ detection; Wi – Fi communication.***

## I. Introduction

CO2 being considered as one among the prime GHGs which are originated due to the coal fires is considered as one of the major reasons to increase the earth's surface temperature. The absorption of $O_2$at the surface of the coal increases the temperature of the coal and results in releasing of energy, when this temperature continues to increase and reaches a point called as threshold point the gases like $CO_2$ are produced [1]. The increase in the temperature if not dropped down by suitable methods such as proper ventilation etc., can trigger fire accidents in the CM resulting in not just financial losses but also on miner's lives. The phenomena commonly referred to as SCC is one among the major reasons of coal fires in India resulting in appearance of about 75% of the coal fires in India [2]and effecting 56% of CMs in China [3]. India, USA, Australia and South Africa are among the many countries where coal fires occurs [4]. So, it can be said that early detection of the heating process through the detection of rise in temperature and $CO_2$ can not only prevent the majority of the coal fires disasters but also provides an alarm indicating the increase in the temperature of coal and emission of GHG ($CO_2$) which has damaging effects on the environment as well as the miners working in the CM environments.

However, it is worth noting that there are certain factors which greatly effects the process called SHC, few of which are listed below:

- Ranking of the coal in the CM;
- Multiple coal seams in the CM;
- Content of moisture found;

- The rate at which the air flows in the CM;
- The depth in the CM;
- Coal seam thickness;
- The quantity of the leftover coal in the CM;
- The time duration for which the coal is stored in the CM environment;
- The strength of the ventilation system being in use;
- The infrastructure of the CM, making sure the airflow is not blocked from reaching certain places;
- The presence of unnecessary obstacles which can block the airflow in the CM;
- The measurements of the pillars in the CM; too thick can block the airflow and reduces the mining area and too thin can result in fall of the roof etc.

The communication method being employed to accomplish the presented research work is based on the Zigbee communication to bring out the temperature and $CO_2$ sensors collected information from the Underground Coal Mine (UCM) which is coupled to the internet communication sub – module for completing the transfer of information to the dedicated monitoring stations or rescue department or any authorized department situated around the World as long as internet connection is maintained. The reason for selecting Zigbee communication for accomplishing such a big responsibility of moving data from the UCM is mainly due to its capabilities such as wide coverage, low power consumption, dynamic networking, flexible working frequency etc., [5].

## II. Sensors Being Used

The LM 35 sensor is used in the proposed research work to detect the change in the temperature in the CM. LM35 is the choice here as the sensor can readily give collected data in Celsius requiring no conversion of data from some form to Celsius. The temperature sensor when checked experimentally was found to be detecting temperatures as low as $0^0$ C to as high as $96^0$ C (the experiment was checked between these temperature level, higher positive or lower negative temperatures can also be obtained based on the limits mentioned in the used sensor specifications).

To carry out the detection of $CO_2$, MQ135 sensor is used. The sensor comes up with the benefits such as its wide detection scope, fast response, ability to be driven and used with the simple drive circuits, high sensitivity etc. The output of the sensor is connected to the transistor based logic circuit. The transistor based sensor circuit contains a potentiometer which allows the user to set the $CO_2$ limit as the threshold exceeding which the NCON (Node Controller) would send a signal to the Main Controller (MCON) to trigger an alarm, turn on the enhanced ventilation system and to send the alert signal to the monitoring station through the use of the internet communication module. The threshold limit of $CO_2$ can be adjusted based on the safety specifications provided for the respective CM by the safety authorities which can differ from CM to CM considering the various factors stated in the previous section.

## III. Methodology:

The methodology being adopted in accomplishing the task of providing safety to the miners and mine infrastructure and surrounding environment is based on detection the two potential indicators of SCC, the phenomena which is stated as one of the major causes of coal fires around the world[6][7]. The early detection of the SHC is provided with the help of detecting and monitoring the temperature variations in the CM, whereas the effects of SCC is prevented through early detection of the increase in the $CO_2$ levels. A reliable communication system is then established through the use of multi nodes to transfer the sensors collected information to the outside unit. The sensor nodes apart from performing detection of $CO_2$ and temperature levels also contains an intermediate or an additional ventilation system to cool down the temperature being build up in the CM, thus ensuring that SCC does not occur and hence preventing the coal fires before it happens.

To extend the range of the alert signals being received at the outside located monitoring, safety or rescue departments; the concept of IoT is implemented. The complete system is implemented following a modular design, thus allowing easy upgradations and troubleshooting to be carried out when required.

**IV. Block Diagrams and Descriptions:**

This section of the paper describes the various parts of the research work and the transfer of sensors collected information between various sub – modules such as the sample nodes, repeater nodes etc. A block diagram of a sample node is shown in the below figure 1, which specifies and describes the functions performed at the sensors node sides in the CM.

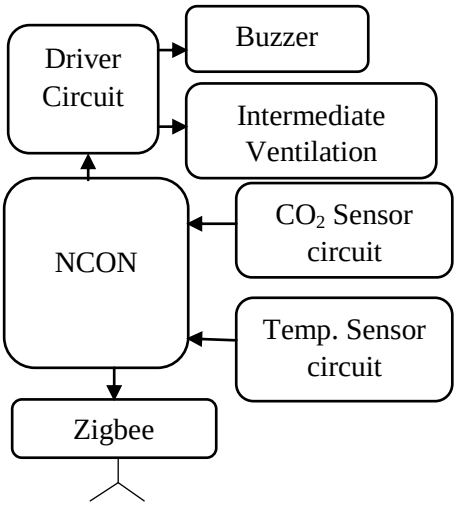


Figure 1. A sample node

The sensors circuit denotes the respective sensors with the associated circuitry to facilitate the ease of adjusting the threshold level of the environmental condition. Similarly, the driver circuit to provide intermediate ventilation contains a current driver and a relay circuit to accomplish the switching operation. The collected information notifying the status of the $CO_2$and temperature levels in the CM, in other words the potential chances of occurrence of SCC, is wirelessly transferred through Zigbee communication to the other node connected in the multi – hop communication; figure 2 showing one the repeater nodes.

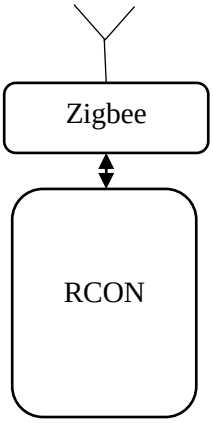


Figure 2. Repeater node

The RCON is the controller circuit built around AT89S52 controller as it not only saves the cost of the system but also performs the operation quite well. The multi – hop Zigbee communication is being implemented so as to obtain a reliable long distance communication in the CM specially in the underground environments where there are turnings, ups and downs in the CM environment. The reliable and quick communication system being one of the major requirements in implementing the CM safety is developed in proposed research work, so as to make sure that the emergency situation data reaches the rescue department and monitoring stations in a quick time ensuring the upmost safety of the miners and the mine infrastructure.

The outdoor unit of the research work contains a final NCON, a MCON to perform the alerting functions according to the loaded set of instructions, an Ethernet controller and a Wi – Fi router connected to the internet connection to wirelessly transfer the data to the outside world. The MCON being used here to perform the alerting functions is built around LPC2148 controller.

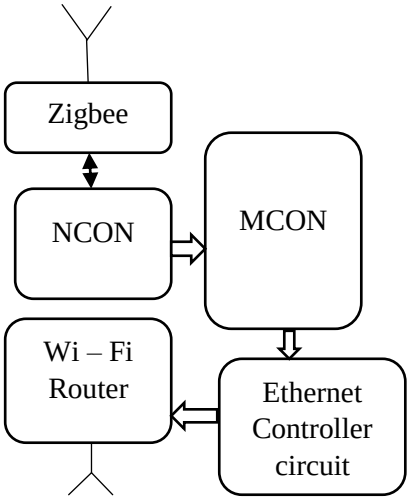


Figure 3. Outside Unit

The Ethernet controller circuit contains a PIC controller to transform the collected information into format suitable to be hosted on a webpage.

## IV. Results

The results obtained with the help of the proposed research work shows that the system is capable of detecting long range temperature values as low as $0^0$ C to $90^0$ C being measured (the range can be extended to detecting greater negative and positive temperatures based on the specifications of the sensors being used). The system offers a reliable and a modular communication system with the ability to adjust the $CO_2$ level considering the various factors which effects SHC. The below figure 4. shows the readings being obtained in normal and emergency situations at the sensor circuits outputs and at the input of the additional ventilation device.

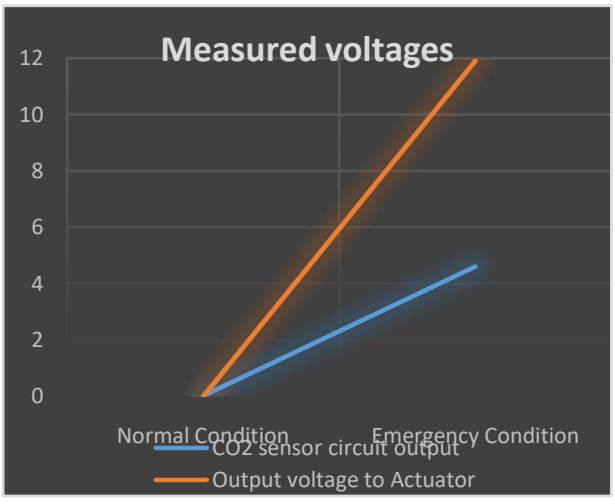


Figure 4. Measured Voltages

The emergency situation here indicates the increase in the temperature or the $CO_2$above the set thresholds. The LM35 provides continuous readings of the temperature based on the temperature in the surrounding environment in the CM. The sensors collected information is accessible throughout the world on a number of devices such as PCs, tabs, laptops, mobile phones etc., as long as internet connection is available [8].

**VI. Conclusion**

The proposed research work being implemented to carry out the safety in the CM will reduce the number of accidents occurring due to SCC by offering various benefits such as extended range of communication through several nodes and internet communication, early detection of the two basic factors which gives information about the possible SCC, modular design to facilitate easy upgradations and troubleshooting, additional ventilation system and economic cost of implementation.

**References**

1. Singh, A., Singh, R., Singh, M., Chandra, H., Shukla, N. (2007). Mine fire gas indices and their application to Indian underground coal mine fires. International Journal of Coal Geology, pp. 192 – 204.

2. Singh, R., (2013). Spontaneous heating and fire in coal mines. The 9th Asia-Oceania Symposium on Fire Science and Technology, pp. 78 – 90.

3. Mao, Z., Zhu, Z., Zhao, X., Sun, J., Wang, Q. (2013). Experimental study on characteristic parameters of coal spontaneous combustion. The 9th Asia-Oceania Symposium on Fire Science and Technology, Vol. 62, pp. 1081 – 1086.

4. Tetuko, S. S. J., Tateishi, R., Takeuchi, N., 2003. A Physical Method to Analyse Scattered Waves from Burnt Coal Seam and its Application to Estimate Thickness of Fire Scars in Central Borneo Using L-Band SAR Data, International Journal of Remote Sensing 24, p. 3119.

5. Yuping, Z., Xiaoling, Y., Chen, L. (2015). Research of the Emergency Communication System in Coal Mine Based on ZigBee Technology. Seventh International Conference on Advanced Communication and Networking, pp. 60 – 63.

6. Liu, t., Li, W., Meng, X., Wei, Y., Hu, J., Zhang, T., Zhao, W. (2014). Advance of fiber optic gas sensors for coal mine safety applications. International Conference on Microwave and Photonics, pp. 1 – 2.

7. De-Ming, W., Xu-Yao, Q., Xiao-Xing, Z., Jun-Jie, G. (2009). Test method for the propensity of coal to spontaneous combustion. The 6th International Conference on Mining Science & Technology, pp. 20 – 26.

8.Mohammed, Z., Ahmed, E. (2017), Internet of Things Applications, Challenges and Related Future Technologies. World Scientific News, pp. 126 – 148.