International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

COPY RIGHT

ELSEVIER SSRN

2023 IJIEMR. Personal use of this material is permitted. Permission from IJIEMR must be obtained for all other uses, in any current or future media, including reprinting/republishing this material for advertising or promotional purposes, creating new collective works, for resale or redistribution to servers or lists, or reuse of any copyrighted component of this work in other works. No Reprint should be done to this paper, all copy right is authenticated to Paper Authors

IJIEMR Transactions, online available on 18th Feb 2022. Link :http://www.ijiemr.org/downloads.php?vol=Volume-12&issue=Issue 02

DOI: 10.48047/IJIEMR/V12/ISSUE 02/62

Title **Hazardous Gases Detection and Alerting System in Underground Coal Mines**

Volume 12, ISSUE 02, Pages: 392-397

Paper Authors

Satya Saketh Kumar. G, Jalalu. G, Sai Siva Rama Krishna. P,

Satya Chandra Shekar. A

USE THIS BARCODE TO ACCESS YOUR ONLINE PAPER

To Secure Your Paper As Per UGC Guidelines We Are Providing A Electronic Bar Code

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

Hazardous Gases Detection and Alerting System in Underground Coal Mines

Satya Saketh Kumar. G
Student, Dept. of EIE , VR Siddhartha Engg. College, Vijayawada, India
sakethkumar963@gmail.com

Jalalu. G
Asst. Prof, Dept. of EIE , VR Siddhartha Engg. College, Vijayawada, India
Jallu.sk@vrsiddhartha.ac.in

Sai Siva Rama Krishna. P
Student, Dept. of EIE, VR Siddhartha Engg. College, Vijayawada, India
ssrkperumalla147@gmail.com

Satya Chandra Shekar. A
Student, Dept. of EIE, VR Siddhartha Engg. College, Vijayawada, India
ascshekar1999@gmail.com

Abstract
For most emerging nations to meet their energy needs, coal mining is crucial. Mining is a dangerous activity, and underground mining poses an exponentially greater risk. Compared to the surface or open-pit mining, underground coal mining has significantly riskier working conditions. Some toxic and hazardous gases are released by the extraction of coal. Hazardous gases that are present in significant quantities can have physiological consequences on the person's body and potentially result in death. Timely Detection of these hazardous gases like carbon monoxide (CO), carbon dioxide (CO2), and dangerous flammable gas like methane (CH4), or in other words firedamp, is a significant problem that must be met to ensure the safety of the mine's workers. In this study, we suggest developing a gas-detection sensor and microcontroller system for mine gas detection. For the detection of methane & carbon Monoxide, MQ-4 and MQ-7 will be used. MQ-135 will be used to detect the smoke. DHT11 sensor is used for the measurement of temperature & humidity. These sensors will be wired into an Arduino board, which will then be wired into an LCD that will display the values on a regular basis. The proposed system detects hazardous gas and provides safety against fire explosions, and poisoned gases like CO, CO2, and CH4 and alerts people in the tunnel.

Keywords— Toxic gases, Fire damp, Arduino board, Miner's safety, Sensors.

Introduction

India is the second largest coal-producing country, with a production of 767 million tonnes in 2021. Most of the coal will be extracted from underground rather than the open-pit mining. Due to the presence of harmful gases like methane and coal dust, underground coal mine operations have always proven to be dangerous. According to reports, explosions caused by coal dust or methane gas account for about 33.8% of fatalities in the mining industry. Even though methane gas has a 5–15% combustible range, exposure to even little amounts of methane can have serious negative effects on a person's health. In addition to methane gas, hazardous gases including carbon dioxide and carbon monoxide (CO) also escape from underground coal mines (CO2). Long-term exposure to these gases almost invariably results in significant body damage, even though short-term exposure to them may not have any negative

effects. Several factors, such as the release of toxic gas, and a rise in the temperature and humidity of the atmosphere, can contribute to mining accidents. Therefore, it's crucial to keep an eye on the mine environment condition and health of the minors. In order to ensure the safety of miners, it is crucial to accurately monitor the surroundings of underground mines. To detect these poisonous gases, various sensors are used. We created a gadget that continuously analyses environmental characteristics such as the level of hazardous gas, temperature, and humidity by merging these features. when the measured level is higher than the threshold level, the sensor senses the level and alerts the miner with the buzzer.

Methodology

In this proposed system the coal mine safety systems are fixed with gas sensor modules, and temperature & humidity sensors. We integrate all the sensors into the Arduino Uno.

This system includes a sensor module made up of various sensors that measure many subterranean characteristics in real-time, including temperature, humidity, smoke, methane, and carbon monoxide. Hazardous gases like methane and carbon monoxide are intended for excess gas concentration. In order to receive sensor outputs and make the necessary decisions, the microcontroller is utilized in conjunction with sensors. The controller decodes beep alarms through the buzzer connected to the controller if the temperature exceeds the safety level pre-programmed at the microcontroller. The microcontroller decodes various beep alert types when the detected humidity value exceeds the safety level that has been pre-programmed Similar to this, the microcontroller decodes siren alarms when the gas concentration exceeds the safety level or threshold limits. For each gas, a different type of beep sound is coming. All the parameters, including temperature, humidity, methane, carbon monoxide, and smoke in percentages, are shown on a 16x2 character LCD module.

Literature Survey

Mostly, accidents in underground coal mines are occurred due to the toxic gases in the mine. Workers are suffering from health issues because of these gases and sometimes this may lead to death. To prevent these issues some are researched this problem and developed a different application process to prevent this.

The MSP430-based proposed design by Dangeetal [1]. Due to climate change and global warming, there are currently challenging issues in the coal mine. Atomization is necessary for the coal mining sector to reduce costs, boost output, and enhance product quality. Additionally, this will reduce the workload for mine workers. This study suggests a wireless sensor network (WSN) system for monitoring temperature, humidity, gas levels, and smoke in underground mines. It uses an MSP430xx controller. This device also controls the miners' ventilation requirements according to the conditions in the minefield at the moment. This system uses a temperature sensor (LM35), a low-power microcontroller (MSP430), To sense the mine climate parameters and regulate the climate state using motor and valve control circuitry, a humidity sensor (SYSH220), a smoke detector, a gas sensor, and a wireless Zigbee transceiver are used in a single location. But this system doesn't alert the workers when abnormal conditions have occurred.

A Zigbee wireless sensor network-based monitoring system designed by Lihuieta [2] for the security of coal mines. The monitoring system collects measurements for Temperature, Humidity, and Methane levels underground in coal mines through Zigbee sensor nodes spread throughout the mine, and then feeds the data to an ARM-based information processing terminal. The terminal sends the data down to the ground via Ethernet, where it is examined by the monitoring center before being published to the LAN for remote users to access. The system can SMS safety personnel if the amount of data reaches the predetermined limit. It is now feasible to keep an eye on the work surface in real-time thanks to this method.

M. Ramya [3] designed a wireless helmet, where temperature, oxygen, ultrasonic, ultraviolet, and gas sensors are

incorporated into a worker's helmet. In mines, if poisonous gases exceed the threshold, it alerts via alarm with the buzzer. The concept was successfully implemented but has a drawback. Workers may have a risk of death because all the sensors are placed in a helmet.

Wakodeetal [4] proposed a system which is frequently used to monitor the concentrations of hazardous gases in coal mines. The safety alerts on the equipment will improve the mine miners' chances of survival. An emergency warning switch is present on both the transceiver and receiver sides. The safety of miners is a serious issue right now. Miners' health and well-being are in danger due to a number of grave issues, including their working environment and its effects. In the mining sector, a novel approach is required to increase output, save costs, and consider worker safety. Coal mine safety monitoring systems based on wireless sensor networks can correctly and instantly relay the changing conditions of personnel in the underground areas to stationary computer systems and mobile units.

Cheng [5] introduced a method based on a ZigBee wireless sensor network and GPRS wireless remote transmission in order to build a wireless coal mine safety monitoring system that supports real-time parameter monitoring and rapid networking. Because of advanced GPRS technology, the associated director can be warned via a quick message sent to his cell phone, which helps to spot severe incidents early and provide real-time treatment, enhancing coal mining safety.

N. Zhigang and W. Lu [6] designed a robot especially for monitoring the gases in underground coal mines. This robot uses infrared spectrum absorption to simultaneously detect methane, and carbon Monoxide. This design is not suitable for underground coal mines because the tunnels are flat. It is difficult to roam around the mine tunnels. Furthermore, this robot requires human operation and does not display continuous parameter values. One more drawback of this design is, it doesn't have an alerting system.

A coal mine safety monitoring system was created by Rajkumar Bodduetal [7]. The typical wired network-based coal mine monitoring systems are replaced in this study with a safe wireless network solution. Ensuring the safe production of coal mines is crucial. Coal mine laneways frequently become monitoring blind areas with a lot of hidden threats due to the ongoing expansion of the mining areas and increase of depth. Inconveniently, wire installation is also expensive and time-consuming. We developed a wireless sensor network-based system for monitoring coal mine safety to address the problems, which might improve production safety monitoring and lower accident rates. Zigbee technology provides guidance to address the coal mine's safety monitoring issues for scientists who make commitments. This study's goals are to offer a workable solution for mining wireless communication and safety monitoring as well as to provide data for further investigation.

Hardware Components

The hardware components used in the creation of the suggested system are discussed in the section that follows:

Arduino UNO

The Arduino Uno is a free and open-source board for microcontrollers that is based on the Microchip ATmega328P processor. Programs for the Arduino platform can be run on Macintosh, Windows, and Linux operating systems, compared to most microcontroller frameworks, which only support Windows (OS). Beginners and amateurs can easily learn and use Arduino programming. An instrument called an Arduino is used to create a computer that is more advanced than a typical desktop model in terms of control, interaction, and sensing. The board's sets of analog input/ output pins (I/O) pins can be used to interface with a variety of expansion boards (shields) and other circuits.

Technical requirements

- Microcontroller: ATmega328
- Operating voltage: 5V
- Digital I/O: 14(of which 6 PWM outputs)

MQ4 Sensor

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

The MQ4 methane gas sensor is widely used to find gas leaks in homes and industries that deal with methane (CH4) and CNG gas which is shown in the below Fig. 4.1. This gas sensor responds quickly and with great accuracy. The concentration range for sensing in this instance is between 300 pm and 10,000 ppm, which is suitable for leak detection. This gas sensor primarily consists of an aluminum-oxide (Al2O3)-based ceramic detecting element that is covered with tin dioxide (SnO2) and mounted within a stainless-steel mesh. The resistivity of the detecting element will change when methane gas and the detecting element come into contact. The concentration of methane gas is then determined by measuring the subsequent change. Methane gas ignites in a highly exothermic manner, which results in a tremendous quantity of heat being produced after it ignites.

Fig. 4.1 MQ4 Methane Gas Sensor

Features

- For flammable gas across a wide range, sensitivity is good.
- Highly sensitive to methane and natural gas
- Fast response, long life, and stable

MQ7 Sensor

This MQ7 sensor is mainly used to detect the Carbon Monoxide (CO) concentration in the air as shown in Fig. 4.2. The concentration ranges from 20 to 2000 ppm. Tin dioxide (SnO2), which has low conductivity in pure air, is the gas sensing component utilized in the MQ-7 gas sensor. The conductivity of the sensor increases with the increase in carbon monoxide gas concentration in the air when carbon monoxide gas is present in the area where the sensor is positioned.

Fig. 4.2 MQ7 Carbon Monoxide sensor

Features

- Sensitive for carbon monoxide
- Quick response and recovery
- Adjustable sensitivity

MQ135 sensor

One of the well-known gas sensors from the MQ series frequently utilized in air quality control equipment is the MQ135 (see Fig. 4.3). When you simply need to detect one particular gas, the MQ-135 sensor module's built-in Digital Pin allows it to function without the aid of a microcontroller. The analog pin must be used to monitor gases in parts per million (PPM). Because the analogue pin is TTL controlled and runs on 5V, it may be used with most common microcontrollers. The MQ135 smoke sensor is shown in the below figure.

Fig. 4.3 MQ135 smoke sensor

Features

- Wide detecting scope
- Stable and long-life simple drive circuit
- Used in air quality control equipment, which is suitable for detecting NH3, NOx, alcohol, Smoke, etc.
- Highly sensitive to Smoke

A. DHT11- Temperature and Humidity Sensor

The DTH11 sensor (see Fig. 4.4) is commonly used to detect Temperature and Humidity. The sensor, as indicated in the Fig. 4.4 below, has an 8-bit

microcontroller for serial data output of temperature and humidity data and a specialized NTC for temperature measurement. Additionally, factory calibrated, the sensor makes it simple to integrate with other microcontrollers.

The sensor can measure humidity between 20% and 90% and temperatures between 0°C and 50°C with an accuracy of 1°C and 1%.

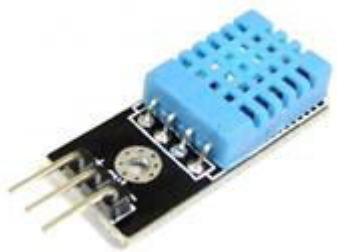

Fig. 4.4 DTH11- Temperature and Humidity Sensor

Specifications

- Operating voltage: 3.5V to 5.5V
- Output: Serial data
- Temperature range: 0°C to 50°C
- Humidity range: 20% to 90%
- Accuracy: ±1°C and ±1%

B. Buzzer

Buzzers (see Fig.4.5) are typically sound-producing devices shown in the figure. If the gas levels exceed the threshold, the buzzer will activate and produces different sounds for different gases which are pre-programmed in Arduino. A buzzer is a little but effective part that adds sound qualities to our project or system.

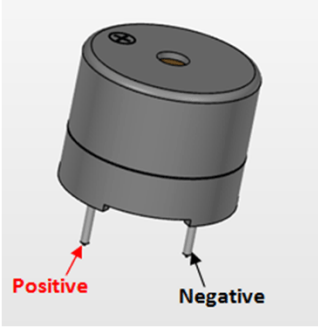

Fig. 4.5 Buzzer

The proposed system (see Fig. 4.6) improves the security and safety of the mine workers by preventing accidents.

Fig. 4.6 Final prototype pictures of the proposed system

The sensors can be used to detect different types of gases whether the concentration of gases is within the limit or not. A humidity sensor detects the atmosphere around it, and if the sensor's value is high, the buzzer is activated. The ambient temperature is detected by the temperature sensor if the temperature value is above the threshold, then the buzzer will alert the miners. Additionally, different gas sensors are used to detect the leakage of hazardous gases like CO, CH4, and smoke.

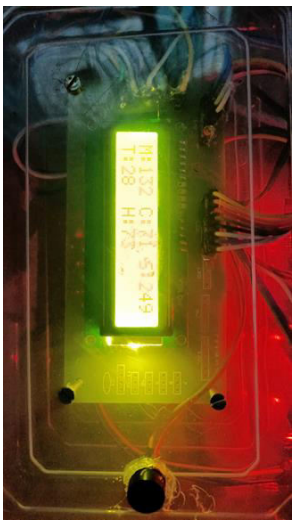

Fig. 4.7 Displayed the gas concentrations on LCD

The temperature, humidity, and gas concentrations are going to be displayed on the LCD shown in above Fig. 4.7.

Conclusion

A monitoring & alerting system for coal mine safety is developed in order to provide a more accurate and thorough view of the underground mine. This system will allow all miners present inside the mine to save their lives before any abnormal conditions occur by displaying the parameters on the LCD at the underground section where the sensor unit is located and on the monitoring unit. When sensor values exceed the threshold level, an alarm is triggered. Gas sensors, temperature, and humidity sensors are used in the implementation of the coal mine safety system to boost worker safety and keep them out of harm's way. This system allows for continuous monitoring of the coal mine and worker alerting. The system is cost-effective and efficient.

Acknowledgement

We express our profound gratitude to our esteemed guide, Sri G. Jalalu, Assistant Professor for his guidance in our project.

We are deeply indebted to Dr. G.N.Swamy, Professor and Head of the Department of Electronics and Instrumentation Engineering for his cooperation given throughout the Mini Project for the facilities provide.

We express our profound gratitude to our beloved principal Dr. A.V. Ratna Prasad and our management for providing library facilities for completing our mini-Project successfully.

References

[1] Dange “Design of Monitoring System for Coal mine safety based on MSP430”, International Journal of Engineering Science Invention (IJESI) Volume2, Issue 7, July 2013

[2] LiHui “Design of Monitoring System for Coal mine safety based on Wireless sensor Networks” 2008 International Conference on Mechatronic and Embedded systems and Applications (ASME).

[3] M. Ramya, “Investigation and Design of Helmet for coal miners”, Indo-Iranian Journal of Scientific Research (IIJSR) Peer-Reviewed Quarterly International Journal, Volume 2, Issue 2, Pages 136-142, April-June 2018

[4] Wakode “Coalmine safety monitoring and alerting system”, International research journal on Engineering and Technology (IRJET) Volume 4, Issue 3, March 2017

[5] Cheng “Coal Mine Safety Monitoring system based on Zigbee and GPRS”, Applied Mechanics and Material Volume 422, 2013

[6] N. Zhigang and W. Lu, "Hazardous Gas Detecting Method Applied in Coal Mine Detection Robot," 2011 Third International Conference on Measuring Technology and Mechatronics Automation, 2011, pp. 308-311, doi: 10.1109/ICMTMA.2011.364.

[7] RajkumarBoddu “Zigbee based mine safety monitoring system with GSM”, International Journal of Computer & Communication Technology ISSN (PRINT): 0975 - 7449, Volume-3, Issue-5, 2012