IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, April 2025
Impact Factor: 7.67

Smart Wearable Suit for Coal Miners using LORA Module

Mr. Yash Tambat, Mr. Piyush Lokhande, Miss. Shruti Nakod, Miss. Vedangi Jayale, Prof. Dr. S. V. Rode
Department of ENTC
SIPNA College of Engineering & Technology, Amravati, Maharashtra, India.

Abstract: *This paper presents a comprehensive study on the mining industry has always been considered one of the most hazardous industries, with coal mining being particularly dangerous due to the risks of explosions, cave-ins, and exposure to toxic gases. As a result, ensuring the safety of miners has always been a top priority for mining companies. In recent years, there have been significant advances in wearable technology, leading to the development of smart safety suit that can enhance the safety of coal miners. In conclusion, the smart safety suit for coal miners represents a significant advance in mining safety technology. By providing real-time data on potential safety risks, it can help miners and safety personnel to make more informed decisions and take proactive steps to mitigate risks. Ultimately, this technology has the potential to reduce accidents and injuries in the mining industry, leading to a safer and more productive workplace for miners. The mining industry, essential for global resource supply, poses significant health and safety risks to workers, particularly in underground environments. This project presents the development of an intelligent safety monitoring system specifically designed for coal miners, aimed at enhancing their safety and well-being. The proposed system integrates advanced sensor technologies within a wearable coat to continuously monitor critical environmental parameters such as humidity, temperature, and concentrations of hazardous gases, alongside real-time health metrics like heart rate. Utilizing LoRa (Long Range) communication technology, the system enables seamless data transmission to a central control station, facilitating immediate alerts and two-way communication. This real- time monitoring allows for the rapid identification of hazardous conditions, enabling timely interventions to mitigate risks. The integration of these technologies promotes proactive safety management, significantly reducing the potential for accidents and health issues.*

Keywords: Wearable Technology, Mine Safety , Sensor Integration , Real-time Monitoring.

I. INTRODUCTION

The mining industry is recognized for its critical role in the global economy, providing essential resources that drive various sectors, including energy, construction, and manufacturing. However, this industry also poses significant risks to the health and safety of its workers, particularly those operating in underground environments. Miners are exposed to numerous hazards, including toxic gases, extreme temperatures, high humidity, and potential structural failures, which can lead to severe accidents and health issues. In recent years, there has been a growing demand for innovative technologies aimed at enhancing safety measures within the mining sector. The advent of smart wearable devices and the Internet of Things (IoT) has opened new avenues for monitoring and managing safety risks in real-time. Recognizing the need for such advancements, this project focuses on developing an intelligent safety monitoring system specifically designed for coal miners. The proposed system integrates advanced sensor technologies and communication methods to continuously monitor both environmental and health parameters. By embedding these sensors within a wearable coat, the system can track critical factors such as humidity, temperature, gas concentrations, and miners' vital signs, ensuring that workers remain safe in potentially hazardous conditions. Additionally, the system utilizes LoRa (Long Range) communication technology to facilitate real-time data transmission between the miners and a central control station. This two-way communication enables prompt alerts and responses to emergencies,

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, April 2025
Impact Factor: 7.67

significantly improving the decision-making process during critical situations. The primary goal of this project is to enhance the safety and well-being of miners by providing a comprehensive monitoring solution that not only detects hazardous conditions but also promotes timely interventions.

II. LITERATURE REVIEW

The research paper focuses on creating a smart system meant to be attached to the helmets worn by coal miners working underground. This intelligent system intends to continuously monitor and assess several crucial hazardous factors present in these mines in real-time. The parameters it will track include humidity levels, temperature, and the concentrations of gases like sulphur dioxide and methane. If certain threshold limits for these factors are exceeded, it could potentially lead to dangerous situations such as flooding, suffocation due to lack of oxygen, gas poisoning, and cave-ins or roof collapses.

This research involves designing a prototype system aimed at detecting various parameters related to the health and safety of miners. It can sense the presence of hazardous gases, monitor the miners' pulse rates, provide real- time updates on temperature and humidity levels, as well as pinpoint the precise depth location and global positioning of each miner. However, a limitation of this research is that it lacks the capability to conduct live video monitoring through a camera.

This research proposes a novel solution aimed at enhancing industrial safety and promoting employee health in the workplace. It introduces a new garment, termed as a "smart suit," which integrates advanced technologies such as the Internet of Things (IoT) and Wireless Body Area Network (WBAN**).** However, a limitation of this project is that it is primarily focused on monitoring the health parameters of miners, thereby restricting its scope.

This study, conducted by Sanjith Krishna, Subashini B., Swethaa Shree V., Rajavarma R., and Jasmin K., focuses on enhancing the safety and health of coal miners, particularly those working in hazardous underground environments. In recent years, research in this field has gained significant attention. Various studies have explored the development of smart systems to mitigate the risks associated with dangerous working conditions in mines. A notable contribution in this area is the development of a smart system designed to be attached to helmets worn by coal miners. This intelligent system continuously monitors several critical hazardous factors in real-time, such as temperature, humidity, and concentrations of dangerous gases, including sulphur dioxide and methane. The rationale behind this system is that exceeding threshold levels of these parameters could lead to catastrophic events like gas poisoning, suffocation due to oxygen depletion, or even structural collapses within the mine. Such real- time monitoring would enable quicker responses to prevent accidents.

III. HARDWARE COMPONENTS

Microcontroller ATmega328P:

The ATmega328P is an 8-bit microcontroller from the AVR family developed by Microchip Technology. It is widely used in embedded systems and microcontroller-based applications due to its efficiency, low power consumption, and ease of programming. The ATmega328P is the core component of several development platforms, including the Arduino Uno.

Fig. 1. Arduino UNO

DOI: 10.48175/IJARSCT-25123

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 4, April 2025 Impact Factor: 7.67

LORA Module:
LoRa (Long Range) is a wireless communication technology designed for low-power, long-range data transmission. It operates on the LoRaWAN (LoRa Wide Area Network) protocol and is widely used in IoT (Internet of Things), industrial automation, and smart city applications. LoRa modules enable communication over kilometers of distance with minimal power consumption, making them ideal for battery-powered devices.

Fig. 2. LORA Module

MQ-137 Ammonia Gas Sensor
The MQ-137 is a gas sensor specifically designed to detect ammonia (NH_3) concentrations in the air. It uses a chemical-sensitive layer that changes resistance when exposed to ammonia gas. This sensor is widely used in air quality systems, industrial safety equipment, and smart farming applications. It outputs an analog voltage that can be read using microcontrollers like Arduino. The MQ-137 offers a low-cost and effective way to monitor ammonia in real-time environments.

Fig. 3. MQ-137 Ammonia Gas Sensor

MQ-8 Sensor (Hydrogen Gas Sensor):
The MQ-8 is a gas sensor designed to detect hydrogen (H_2) gas in the air. It operates on a heated tin dioxide (SnO_2) sensing element, which changes resistance when exposed to hydrogen. The sensor provides an analog output that increases with gas concentration. It is commonly used in gas leakage detection systems, industrial safety, and hydrogen-powered vehicles.

Fig. 4. MQ-8 Sensor (Hydrogen Gas Sensor)

MQ-136 Sensor (Sulfur Dioxide Gas Sensor):
The MQ-136 is a gas sensor specifically designed to detect sulfur dioxide (SO_2). It also uses a SnO_2-based sensing element that reacts to SO_2 gas, producing an analog output proportional to the gas concentration. It is widely used in air pollution monitoring, industrial emissions control, and environmental protection systems.

Fig. 5. MQ-136 Sensor (Sulfur Dioxide Gas Sensor)

DHT22 (Temperature and Humidity Sensor):

The DHT22 is a digital sensor used to measure temperature and humidity with high accuracy. It has a capacitive humidity sensor and a thermistor to provide digital output via a single-wire interface. The sensor operates within a temperature range of -40°C to 80°C and a humidity range of 0% to 100% RH. It is commonly used in weather monitoring, HVAC systems, and IoT-based climate control applications.

Fig. 6. DHT22 (Temperature and Humidity Sensor)

Pulse Oxy Sensor:

A Pulse Oximeter Sensor measures blood oxygen saturation (SpO_2) and pulse rate (BPM) using infrared and red LED light absorption. It works on the principle of photoplethysmography (PPG), detecting oxygen levels by analyzing light absorption in the blood. These sensors are widely used in medical devices, wearable health monitors, and fitness trackers to monitor oxygen levels and heart rate in real-time.

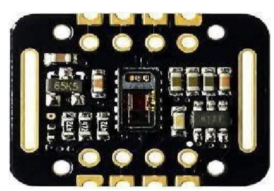


Fig. 7. Pulse Oxy Sensor

USB-C BMS (Battery Management System):

A USB-C BMS (Battery Management System) is a circuit used for charging, balancing, and protecting lithium-ion (Li-ion) or lithium-polymer (LiPo) batteries via a USB-C interface. It manages overcharge, over-discharge, short circuits, andtemperature protection to enhance battery life and safety. Common applications include portable electronics, power banks, and electric vehicles (EVs).

Fig. 8. USB-C BMS (Battery Management System)

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, April 2025
Impact Factor: 7.67

Overalls Suit:

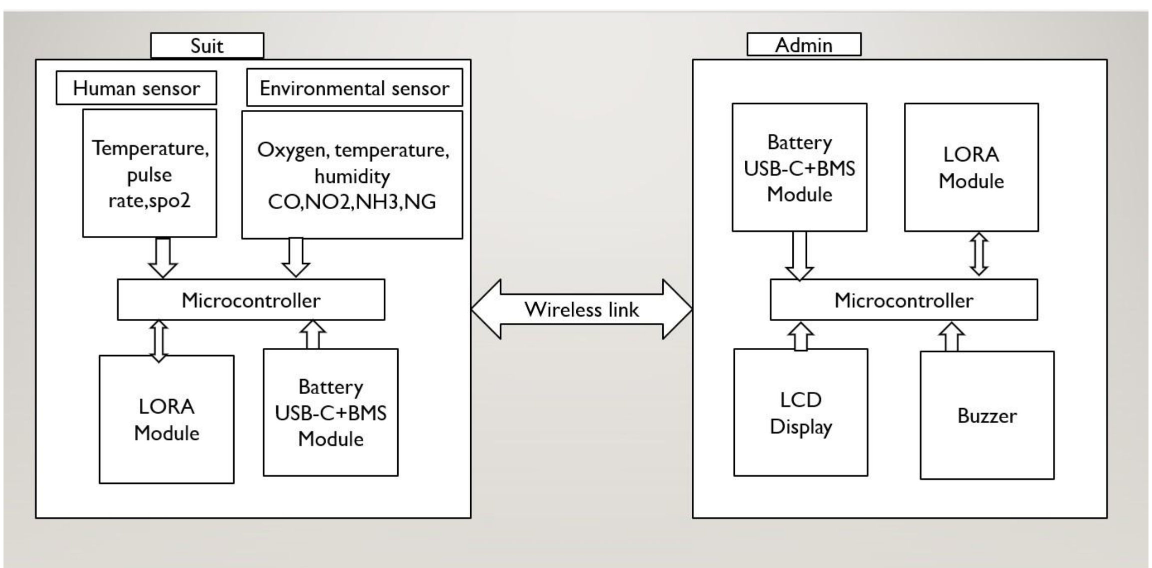
An overalls suit (coverall) is a one-piece protective garment used in industries for safety and comfort. It provides full-body coverage, protecting against dirt, chemicals, and fire hazards. Made from cotton, polyester, or flame-resistant fabric, it includes reflective strips for visibility. Commonly used in construction, mining, oil fields, and industrial work for worker protection.

Fig. 9. Overalls Suit

IV. METHEDOLOGY

The Smart Wearable Suit for Miners is developed through a structured approach involving hardware selection, system integration, and real-time monitoring. Initially, research is conducted to identify the key hazards in mining environments, such as toxic gases, extreme temperatures, and worker health risks. Based on this analysis, appropriate sensors are selected, including gas sensors (MQ-7, MQ-136, MICS-6814) for detecting harmful gases, a temperature and humidity sensor (DHT22) for environmental monitoring, and a pulse oximeter sensor for tracking miners' health parameters.

A microcontroller (ATmega328p or ESP32) is used to process the collected data efficiently. To ensure real-time safety monitoring, a wireless communication module (LoRa or Zigbee) is integrated, allowing seamless transmission of data to a remote monitoring system. This enables quick response to hazardous conditions, ensuring enhanced safety for miners.



The Smart Wearable Suit for Miners is developed through a structured approach involving hardware selection, system integration, and real-time monitoring. Initially, research is conducted to identify the key hazards in mining environments, such as toxic gases, extreme temperatures, and worker health risks. Based on this analysis, appropriate sensors are selected, including gas sensors (MQ-7, MQ-136, MICS-6814) for detecting harmful gases, a temperature and humidity sensor (DHT22) for environmental monitoring, and a pulse oximeter sensor for tracking miners' health parameters.

A microcontroller (ATmega328p or ESP32) is used to process the collected data efficiently. To ensure real-time safety monitoring, a wireless communication module (LoRa or Zigbee) is integrated, allowing seamless transmission of data to a remote monitoring system. This enables quick response to hazardous conditions, ensuring enhanced safety for miners. The suit also incorporates alert mechanisms such as buzzers, LED indicators, and vibration motors to notify miners immediately of any dangerous situations.

For power management, the suit is equipped with a rechargeable battery and a Battery Management System (BMS) to ensure long operational hours. The collected data is analyzed using microcontroller-based processing and cloud storage, enabling predictive analytics for early warning systems. The final phase involves extensive testing and validation, including lab simulations and real-world mining conditions, to ensure sensor accuracy, durability, and user comfort. The system is then optimized based on feedback from miners and industry experts, ensuring a reliable, efficient, and life-saving wearable solution.

REFERENCES

[1]. P. Kulkarni, Sangam, Smart System for Hazardous Event Detection and Evaluation in Mining Industries, Int. J. Inov. Res. Electr. Electron. Instrum. Control eng, 5, 3 (2017)

[2]. Dhanalakshmi and Lathapriya, A Smart Helmet for Improving Safety in Mining Industry, Int. J. Innov. Sci. Res. Technol. 2, 3 (2017)

[3]. Kwon, G.H., Smith-Jackson, T.L., Bostian, C.W.: Socio-cognitive aspects of inter-operability: Understanding communication task environments among different organizations. ACM Transactions on Computer-Human Interaction.18,1–21(2011)

[4]. D. Kock and J. W. Oberholzer, THE DEVELOPMENT AND APPLICATION OF ELECTRONIC TECHNOLOGY

[5]. TO INCREASE HEALTH, SAFETY, and productivity in the South African coal mining industry," IEEE Trans. on Industry Applications, vol. 33,no 1997. [1]

[6]. Singh, U.K. Singh, IoT in Mining for Sensing, Monitoring and Prediction of Underground Mines Roof Support, IEEE, (2018)

[7]. Arun Katara, Anand Danstate Abhilesh Chore. Ama Bhandarwat 2015 Firth International Conference on Communication Stems and Network Technology 'Zig-Bee Based Intelligent Helmet For Coal Miner' Pages: 314-317, DOI: 10.1109/CSNT 2015.147 IEEE Conference Publications. 2015

[8]. Shabina S. 'Smart Helmet Using RF and WSN Technology for Underground Mines Safety' 2014 International Conference on Intelliet Computing Applications Pages: 305-309, DOI: 10.1109/ICICA.2014.105 IEEE Conference Publications 2014.

[9]. Lymberis, A. (2003, April). Smart wearables for remote health monitoring, from prevention to rehabilitation: current R&D, future challenges. In Information Technology Applications in Biomedicine, 2003. 4th International IEEE EMBS Special Topic Conference on (pp. 272- 275). IEEE.

[10]. Sabeenian R.S, Kanishka K, " Smart Wearable Safety Suits For Coal Miners" Department of ECE, K.Ramakrishnan College of Technology, Trichy - 621112, Tamil Nadu, India E3S Web of Conferences 399, 04014 (2023).

[11]. Digvijay Guleria, Konagani Karthik, Dr.Ajay Roy,"Smart Wearable Safety Suits For Coal Miners" Department of Electronic and Communicational Engineering, Lovely Professional University, Chaheru, Phagwara, Punjab, India May 2022 | IJIRT | Volume 8 Issue 12 | ISSN: 2349-6002.