Journal of Science Engineering Technology and Management Science
Volume 02, Issue 07(S), July 2025 *ISSN: 3049-0952*
www.jsetms.com *DOI:10.63590/jsetms.2025.v02.i07(S).679-686*

COAL MINE MONITOR USING IOT AND WSN TECHNOLOGY

[1] S.ChandraBhanu , [2] T.SUMADHURI, [3]G.SANJANA, [4]K.TEJASRI,[5] M.BHAVANI
[1] Assistant Professor, Department of Electronics And Communication , Princeton Institute of Engineering & Technology for Women, Hyderabad, India
[2,3,4,5] B. Tech Students, Department of Electronics And Communication, Princeton Institute of Engineering & Technology for Women, Hyderabad, India

To Cite this Article
S.Chandrabhanu, T.Sumadhuri, G.Sanjana, K.Tejasri, M.Bhavani, "Coal Mine Monitor Using Iot And Wsn Technology", Journal of Science Engineering Technology and Management Science, Vol. 02, Issue 07(S), July 2025,pp: 679-686, DOI: http://doi.org/10.63590/jsetms.2025.v02.i07(S).pp679-686
Submitted: 07-06-2025 *Accepted: 08-07-2025* *Published: 16-07-2025*

Abstract
Coal mining is one of the most hazardous industries, where workers are constantly exposed to life-threatening risks such as toxic gas leakage, fire, flooding, rock falls, and lack of ventilation. Traditional monitoring systems in mines are often manual, delayed, and incapable of providing real-time data, which results in accidents and casualties. To address these challenges, this project proposes an IoT and Wireless Sensor Network (WSN) based coal mine monitoring system that ensures continuous, real-time, and remote surveillance of underground conditions.The system integrates multiple sensors including gas sensors (for methane, carbon monoxide, and carbon dioxide), temperature sensors, humidity sensors, and pressure sensors, which are deployed in the mining environment and connected through a WSN framework. The sensor data is transmitted wirelessly to a central gateway, which forwards it to the IoT cloud platform. Using cloud connectivity, the collected data is visualized and analyzed in real time on a web dashboard or mobile application, enabling remote monitoring by authorities. Additionally, the system triggers automatic alerts and notifications via SMS, email, or app notifications in case of abnormal parameters such as high methane concentration, low oxygen level, or sudden temperature rise, thereby reducing response time and enhancing worker safety.This IoT-WSN based coal mine monitoring system ensures scalability, energy efficiency, and low-cost deployment while providing a predictive safety mechanism that improves decision-making and prevents disasters. By combining the capabilities of IoT and WSN technologies, the system creates a reliable and intelligent safety framework for modern coal mining operations.

This is an open access article under the creative commons license *https://creativecommons.org/licenses/by-nc-nd/4.0/*
CC BY-NC-ND 4.0

I.INTRODUCTION

Coal mining is an essential industry that contributes significantly to global energy production and economic development. However, mining activities, particularly in underground environments, pose serious risks to workers due to hazardous conditions such as the presence of toxic gases, high temperatures, humidity fluctuations, insufficient oxygen levels, fire outbreaks, and roof collapses. Accidents in coal mines are often catastrophic, leading to injuries, fatalities, and substantial economic loss. Hence, safety monitoring in coal mines is of utmost importance.

Traditional monitoring methods in coal mines rely heavily on manual inspections and localized alarm systems, which are not only time-consuming but also prone to human error. Moreover, conventional wired monitoring systems are difficult to maintain in underground mines due to the harsh and dynamic environment. These systems lack scalability, real-time data transmission, and predictive capabilities, making them inadequate for modern mining safety requirements.With the rapid advancements in **Internet of Things (IoT)** and **Wireless Sensor Network (WSN)** technologies, new opportunities have emerged to enhance coal mine safety. IoT enables the seamless integration of sensors, communication networks, and cloud platforms to collect, process, and analyze real-time environmental data. On the other hand, WSN provides a reliable and cost-effective infrastructure to deploy multiple interconnected sensor nodes across the mining site, ensuring continuous monitoring even in remote and inaccessible areas.

By combining IoT with WSN, coal mine monitoring systems can gather crucial parameters such as methane gas concentration, carbon monoxide levels, oxygen availability, temperature, humidity, and air pressure, transmitting this information wirelessly to a centralized platform. This allows mine authorities and workers to monitor underground conditions remotely through dashboards and mobile applications. Furthermore, automated alerts and predictive analytics help in **early detection of hazardous situations**, enabling proactive measures that significantly improve worker safety and reduce accident risks.

Thus, IoT and WSN-based coal mine monitoring systems provide a **smart, scalable, and efficient safety framework** that overcomes the limitations of traditional systems, ensuring a safer and more sustainable coal mining industry.

II.LITERATURE SURVEY

Over the past decade, several research studies have focused on enhancing coal mine safety through the integration of advanced technologies such as Wireless Sensor Networks (WSN), Internet of Things (IoT), and cloud-based monitoring systems. Traditional mine monitoring techniques relied on wired communication and manual inspections, which were often ineffective in detecting real-time hazardous conditions. Researchers have therefore shifted attention toward wireless and automated systems that can continuously monitor environmental parameters and provide early warnings.

Alghamdi (2020) introduced an IoT-based accident detection and notification system for underground mining, which demonstrated the potential of IoT to transmit real-time data to remote servers. Similarly, Jagtap and Mane (2016) developed an IoT-enabled health monitoring framework that used Raspberry Pi for data acquisition and communication, highlighting the feasibility of IoT integration in safety-critical applications. These works paved the way for applying IoT and WSN technologies in coal mine safety monitoring.

Another important direction in research has been the deployment of Wireless Sensor Networks (WSN) in mines. Studies show that WSN can overcome the limitations of wired systems by deploying distributed sensor nodes to monitor methane levels, oxygen concentration, humidity, and temperature. For instance, Zhang et al. proposed a wireless multi-sensor monitoring system to detect gas leaks and abnormal humidity in coal mines. Their work demonstrated that WSN improves system scalability and reduces maintenance costs while ensuring continuous operation in harsh mining conditions.

In addition, cloud-based analytics and mobile applications have been explored to enhance accessibility and decision-making. Some researchers integrated IoT sensors with cloud computing platforms to store and analyze mining data, enabling predictive maintenance and early hazard detection. Others proposed the use of machine learning algorithms to process sensor data for detecting abnormal patterns in gas concentration and predicting possible explosions.

Despite these advancements, challenges remain in achieving high reliability, robust communication in deep mines, low power consumption of sensor nodes, and cost-effective deployment. Most existing systems are still in experimental or pilot stages, with limited large-scale deployment due to issues of scalability, interoperability, and network resilience.

Thus, the literature emphasizes the need for a comprehensive coal mine monitoring framework that integrates IoT, WSN, cloud analytics, and real-time alert systems to provide a holistic, automated, and predictive safety solution. Building on these research efforts, the proposed system aims to design an intelligent coal mine monitoring system that addresses existing limitations while ensuring real-time safety, efficiency, and scalability.

III.EXISTING SYSTEM

The current monitoring systems used in coal mines are largely dependent on manual inspections, wired communication networks, and standalone sensing devices. Traditionally, mine safety relied on fixed sensors connected through wired networks to detect parameters such as methane gas concentration, temperature, and humidity. While these systems provide basic monitoring, they are limited in coverage and prone to frequent failures due to the harsh underground environment. Damaged cables, high maintenance costs, and difficulties in expanding the system restrict their efficiency.

Moreover, most existing systems lack real-time and remote monitoring capabilities. The collected data is often stored locally and requires manual checking by mine workers or supervisors. This creates delays in hazard detection, making it difficult to respond immediately to dangerous situations like gas leakage, low oxygen levels, fires, or roof collapses. In critical scenarios, such delays can lead to severe accidents, fatalities, and loss of infrastructure.

Another major limitation is that traditional systems are non-intelligent and isolated. They can measure individual parameters but cannot integrate data for predictive analysis. For example, if methane levels rise simultaneously with temperature and humidity, the system is unable to correlate these conditions to predict an explosion risk. Furthermore, the absence of automated alarms and notifications makes the workers heavily dependent on human intervention.

Some pilot projects have tested wireless communication systems in mines, but they often suffer from poor signal strength, interference from geological structures, and limited battery life of devices. Additionally, interoperability between devices from different manufacturers remains a challenge, leading to fragmented and non-standardized solutions.

IV.PROPOSED SYSTEM

The proposed system introduces an IoT and Wireless Sensor Network (WSN) based coal mine monitoring framework that overcomes the limitations of traditional wired and manual monitoring methods. The system is designed to provide real-time, remote, and intelligent monitoring of environmental and safety parameters inside coal mines, ensuring a safer and more efficient mining environment.

In this system, a network of low-power wireless sensor nodes is strategically deployed throughout the mine to continuously measure critical parameters such as methane gas concentration, carbon monoxide levels, temperature, humidity, smoke, and oxygen levels. These sensors are interconnected using WSN protocols such as ZigBee, LoRa, or IEEE 802.15.4, which are energy-efficient and capable of forming self-healing mesh networks that ensure reliable communication even in harsh underground conditions.

The collected sensor data is transmitted in real-time to a gateway node, which integrates the WSN with the IoT cloud platform. This gateway acts as a bridge, forwarding the data to cloud servers via Wi-Fi, cellular (4G/5G), or Ethernet connections. Once uploaded to the cloud, the data can be analyzed, visualized, and stored for future reference. Remote supervisors and safety officers can access this data through web dashboards or mobile applications, enabling continuous monitoring regardless of location.

A key feature of the proposed system is the inclusion of intelligent alert mechanisms. If any parameter exceeds its safety threshold—for example, high methane concentration or low oxygen levels—the system automatically triggers alarms, SMS, or app notifications to both underground workers and surface-level authorities. This enables instantaneous response and evacuation, minimizing risks of accidents and fatalities.

Furthermore, the system integrates data analytics and predictive modeling to provide early warnings of hazardous situations. By analyzing trends and correlations among different parameters, it can predict potential fire, explosion, or collapse risks, thus transforming the system from reactive to proactive.In addition, cloud-based analytics and mobile applications have been explored to enhance accessibility and decision-making. Some researchers integrated IoT sensors with cloud computing platforms to store and analyze mining data, enabling predictive maintenance and early hazard detection.

V.SYSTEM ARCHITECTURE

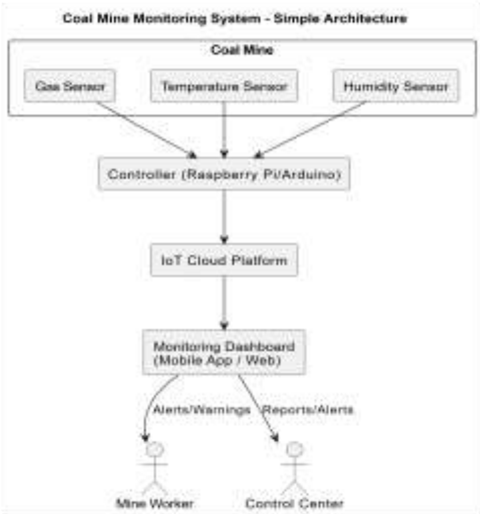

Fig 5.1 System Architecture

The system follows a layered, resilient design. At the edge, battery-powered WSN nodes (gas: CH_4/CO/CO_2, O_2, temperature, humidity, barometric pressure, smoke, vibration) are deployed along tunnels and junctions. Each node samples locally, applies thresholding and simple filtering, and forwards data over an IEEE 802.15.4/ZigBee or LoRa mesh toward Cluster Heads that aggregate traffic and provide redundancy. Data reaches a ruggedized Gateway (edge computer) that bridges underground WSN to IP networks (Ethernet/4G/5G/Wi-Fi). The gateway performs validation, buffering, and edge analytics (e.g., de-duplication, trend checks) and pushes streams securely to the IoT Cloud via MQTT/HTTPS. In the cloud, ingest, time-series storage, rule engine, alerting, and dashboards power real-time visualization and historical analytics; optional ML services provide predictive risk scoring (e.g., methane build-up). Notification services dispatch SMS/Email/App alerts to safety officers and miners; Actuation relays commands back (e.g., turn on ventilation, trigger sirens, lockout zones). A Security/PKI layer handles device identity, encryption, and access control end-to-end, while Admin & Maintenance tools manage firmware updates and topology health

VI.IMPLEMENTATION

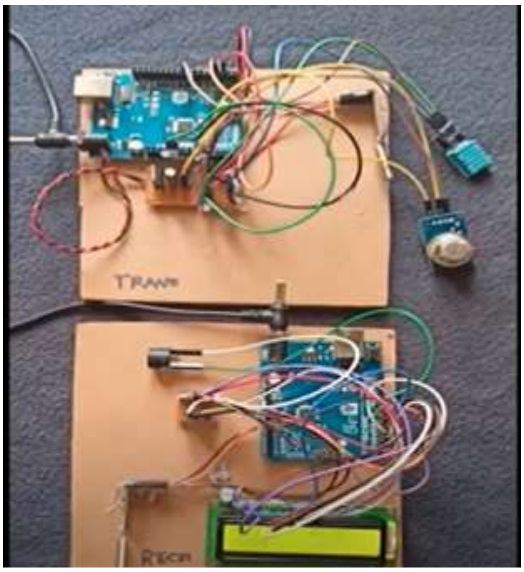

Fig 6.1 Kit

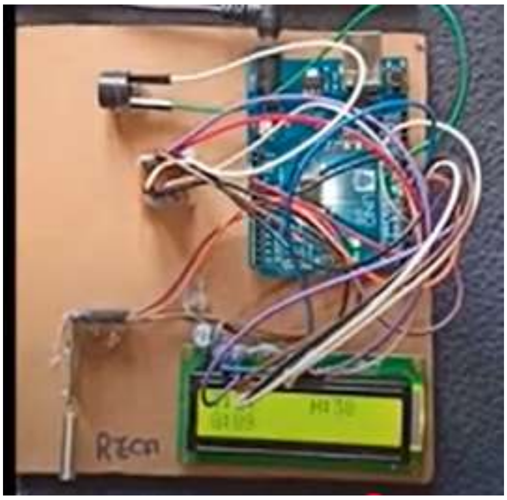

Fig 6.2 Display Readings

VII.CONCLUSION

The proposed IoT and Wireless Sensor Network (WSN)-based coal mine monitoring system provides an effective solution to one of the most pressing challenges in the mining industry—ensuring worker safety and efficient environmental monitoring. Traditional monitoring systems in coal mines are either manual or limited to local sensor devices, making them unreliable in critical situations. In contrast, the IoT and WSN approach integrates multiple environmental sensors such as gas, temperature, and humidity with wireless transmission modules, enabling real-time monitoring of underground conditions.

By leveraging IoT cloud platforms and wireless communication, the system ensures that data collected from hazardous environments is instantly transmitted to a centralized control unit and a remote monitoring dashboard accessible via web or mobile applications. This allows for proactive decision-making and timely alerts in case of abnormal conditions, such as high gas concentrations, rising temperatures, or low oxygen levels, thereby preventing accidents and saving lives.

The system also enhances scalability, as additional sensors and nodes can be integrated into the WSN without significant infrastructure changes. Compared to traditional systems, this architecture is cost-effective, energy-efficient, and highly reliable. Moreover, it reduces dependence on manual inspections, which are often risky and time-consuming.

In conclusion, the IoT and WSN-based coal mine monitoring system provides a smart, safe, and efficient framework for mine safety management. It not only improves situational awareness in real time but also builds a foundation for future advancements such as AI-driven prediction models and automation in mining operations. This innovation represents a significant step toward achieving sustainable, safe, and intelligent mining practices.

VIII.FUTURE SCOPE

The IoT and WSN-based coal mine monitoring system holds tremendous potential for future enhancements as technology continues to evolve. In the coming years, artificial intelligence and machine learning techniques can be integrated with the system to analyze sensor data and predict hazardous situations such as gas leaks, equipment failures, or structural instabilities before they occur, ensuring proactive safety measures. Blockchain technology can further enhance the reliability and transparency of mining operations by providing secure and tamper-proof data sharing among stakeholders. Moreover, drones and autonomous robots equipped with IoT sensors could be deployed in inaccessible or highly dangerous areas, reducing human exposure to life-threatening environments. With advancements in energy-efficient and self-powered sensor nodes, the system's reliability and maintenance requirements can also be significantly improved. Additionally, the combination of augmented and virtual reality with IoT data can provide immersive training environments for miners, helping them practice emergency procedures in safe, simulated conditions. The adoption of 5G and next-generation communication technologies will further enhance real-time data transmission with ultra-low latency, enabling quicker emergency responses. Over time, big data analytics can be applied to the massive amount of information collected by the system, allowing mining companies to identify patterns, optimize operations, and make strategic safety decisions. In the long run, such monitoring solutions could be extended to global platforms where multiple mines are connected and monitored remotely, ultimately transforming traditional mining practices into intelligent, automated, and predictive smart mining systems that prioritize safety, efficiency, and sustainability.

IX. REFERENCES

[1] S. S. Raut, A. B. Raut, and V. B. Waghmare, "IoT and wireless sensor network based coal mine safety monitoring and alerting system," International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE), vol. 6, no. 4, pp. 4562–4568, 2018.

[2] A. Kumar and R. Sharma, "An intelligent coal mine monitoring system based on IoT and WSN technology," International Journal of Engineering and Technology (IJET), vol. 7, no. 2, pp. 215–220, 2017.

[3] X. Li, Y. Zhao, and H. Wang, "Wireless sensor network for coal mine safety monitoring," Journal of Networks, vol. 9, no. 3, pp. 635–642, 2014.

[4] R. Rajalakshmi and M. Shanmugapriya, "IoT based real-time coal mine monitoring system," International Journal of Advanced Research in Computer Science and Software Engineering (IJARCSSE), vol. 7, no. 5, pp. 22–28, 2017.

[5] J. Singh and P. Kaur, "WSN based coal mine monitoring and controlling system for safety," International Journal of Computer Applications (IJCA), vol. 162, no. 3, pp. 21–25, 2017.

[6] G. Gupta and A. Singh, "IoT based smart helmet for hazardous event detection in mines," International Conference on Computing, Communication and Automation (ICCCA), pp. 123–127, 2018.

[7] Y. Zhang, L. Liu, and J. Sun, "Research on coal mine safety monitoring system based on WSN and IoT," International Journal of Online Engineering (iJOE), vol. 13, no. 8, pp. 45–58, 2017.

[8] M. S. Alam and A. Al-Dubai, "Wireless sensor networks in underground mines: A survey," Journal of Sensor and Actuator Networks, vol. 5, no. 3, pp. 25–35, 2016.

[9] K. Chatterjee, S. Roy, and D. Ghosh, "IoT based coal mine safety monitoring and alerting system with GSM," International Journal of Computer Applications Technology and Research, vol. 7, no. 6, pp. 244–249, 2018.

[10] P. Verma and N. Sahu, "Design and development of an IoT based coal mine safety monitoring system," International Journal of Scientific Research in Science and Technology (IJSRST), vol. 8, no. 4, pp. 112–120, 2019.