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VIGYAAN

DEPARTMENT OF MINING ENGINEERING

PROBLEM STATEMENTS

MIN01: Advanced Tailings Dam Stability Monitoring System

Develop an advanced tailings dam monitoring system that continuously evaluates structural stability to prevent catastrophic failures in mining operations. The solution should integrate distributed sensing and predictive analytical methods to assess geotechnical conditions in real time, identify early indicators of instability and provide timely alerts that support regulatory compliance, environmental protection and operational safety.

MIN02: Wireless Sensor Network for Underground Mining Safety

Develop a wireless sensor network optimized for underground mining environments to enable continuous monitoring of critical environmental and operational parameters. The solution should reliably track air quality, ground stability, water presence and equipment performance while maintaining reliable communication under harsh subterranean conditions, supporting proactive hazard mitigation, worker safety and integration with existing mine safety and operations systems.

MIN03: Smart PPE Compliance and Safety Monitoring System for Mines

Develop a smart personal protective equipment monitoring system for mining environments that enhances worker safety by ensuring proper equipment usage and providing real-time awareness of hazardous conditions. The solution should continuously track key safety parameters, monitor worker location and exposure risks and deliver alerts to both workers and safety personnel, while seamlessly integrating into existing mine safety management workflows without compromising the functionality of PPE.

MIN04: Intelligent Drilling Optimization and Control System

Develop an intelligent drilling optimization system that analyzes key operational parameters and dynamically adjusts drilling conditions to improve penetration rate, maintain borehole quality and extend equipment life, while minimizing energy consumption. The solution should enable real-time performance assessment, adapt to varying geological conditions and support safer, more efficient drilling operations through continuous data-driven optimization.

MIN05: Exploration of Underlying Coal Seams in Active Mines

Develop a rapid and non-disruptive exploration methodology to investigate deeper coal seams underlying active mining operations. The solution should be deployable from within existing mine workings and capable of delivering high-resolution subsurface information, including geological structure, seam thickness and associated gas or stress conditions. The methodology must enhance resource estimation accuracy, enable proactive hazard mitigation and support safe, efficient long-term mine planning aimed at maximizing recoverable reserves.

MIN06: Predictive Analytics for Slope Stability in Open-Cast Mines

Develop predictive analytical systems for slope stability monitoring in open-cast mines by integrating real-time geotechnical and environmental data to identify early signs of instability. The solution should forecast potential slope failures in real time, enabling proactive hazard mitigation and improved decision-making in slope design, blasting operations and mine planning to protect workers, equipment and mine productivity.

MIN07: Low-Cost Mine Water Desalination for Industrial Reuse

Develop a low-cost and energy-efficient mine water desalination system that enables safe reuse of treated water for industrial applications such as dust suppression, drilling operations and local agricultural needs. The solution should support decentralized deployment, improve water sustainability in mining regions and reduce dependence on freshwater resources by providing reliable treatment performance under variable mine-water quality conditions.

MIN08: Energy Harvesting from Mine Ventilation Airflows

Develop an energy-harvesting system that utilizes mine ventilation airflows to generate power for low-consumption devices within underground mining environments. The solution should convert the kinetic energy of ventilation air into usable electrical energy, ensuring reliable operation under variable airflow conditions. It must support enhanced energy efficiency, reduce dependency on external power sources and demonstrate feasibility for integration into existing mine infrastructure to promote sustainable mining practices.

MIN09: Modular Support Systems for Quick Recovery in Weak Roof Conditions

Develop a modular roof support system that can be rapidly deployed in underground mines to stabilize weak roof conditions and enhance worker safety. The solution should be lightweight, easy to install during emergency situations and capable of improving productivity by reducing downtime associated with roof instability. The design must be practical for small and medium-scale mining operations where quick recovery and adaptable support systems are essential.

MIN10: Digital Twin for Underground Mines

Develop a scaled digital twin model of an underground mine that can simulate real-time environmental and operational conditions. The system should integrate sensing capabilities to monitor key parameters such as ventilation, equipment movement and potential hazards, enabling visualization and scenario-based analysis. This digital twin should support safer mine planning, predictive decision-making and training without disrupting actual mining operations.

MIN11: Mine Vehicle Anti-Collision System

Develop a low-cost anti-collision alert system for mine vehicles to improve safety in environments with limited visibility and congested traffic conditions. The solution should detect nearby obstacles, equipment, or personnel and provide timely warnings to operators to help prevent accidents, reduce downtime and enhance overall traffic safety in underground or surface mine operations. The design should be practical for adoption in mixed-fleet mining environments and suitable for integration into affordable safety kits.

MIN12: <u>Waste Heat Recovery from Mining Equipment Exhausts</u>

Develop a waste heat recovery solution for mining equipment exhaust systems that captures and converts thermal energy into usable power for auxiliary functions. The system should enhance energy efficiency, reduce fuel consumption and contribute to lower emissions in mining operations. The design must be practical for integration into existing heavy machinery and suitable for improving sustainability in both surface and underground mining environments.

MIN13: <u>AI-Based Mobile Application for Ore Grade Prediction Using Portable Sensors</u>

Develop an AI-based mobile application that can estimate ore grade on-site using data from portable sensing technologies. The solution should enable faster and more reliable decision-making during mining and exploration activities by reducing dependency on laboratory analysis. The system must be user-friendly for field personnel and demonstrate potential for improving resource recovery, cost efficiency and productivity in mine operations.

MIN14: <u>Circular Economy in Mine Closure – Overburden to Marketable Products</u>

Develop an innovative solution to convert overburden materials from mining operations into useful and marketable products, supporting a circular economy approach during mine closure. The design should reduce waste disposal impacts, promote resource recovery and create opportunities for economic development in mining communities. The system should be environmentally sustainable, technically feasible at small scale and adaptable for wider deployment in real mine rehabilitation projects.