

PRODUCTIVITY Improvement In Coal Mines – ROLE OF AI

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Abstract

The coal production in India in 2024-25 is 1047.57 MT in comparison to 997.83 MT in 2023-24 from all the sources ie Coal India Ltd, Singreni Collieries company Ltd, captive mines and other private players. The major producer of coal in the country is CIL and it is also one of the largest coal producers of the world which produced 781.06 MT of coal which is about 74.52 % of total Indian coal production. This paper focuses on adoption of latest technologies including AI for productivity enhancements in opencast mine.

1. Introduction

Presently, coal accounts for approximately 74% of the total power generation and 55% of the national energy mix. Coal is expected to remain the primary energy source, with its share projected to not dip below 40% until at least 2070 (Blinova et al., 2023). This study aims to evaluate the impact of introduction latest as well as high capacity technology in opencast mines for increasing production & productivity, decreasing environmental impact, reducing accidents etc.

2. Literature Review

The mining operations are undergoing drastic changes for efficiency improvement through the adoption of advanced smart mining technology, as emphasized by Xie et al. (2010). The adoption of latest technology allows mining companies to automate different production processes as well as information system. The adoption of technology ensures increase in productivity, reduction of downtime of machines, proper loading of machines in case of breakdown, cost reduction, improvement in safety standards. Incorporating remote-controlled or autonomous mining vehicles (by Zhang et al. 2016), eliminates human involvement in hazardous tasks,

thereby reducing the risk of accidents. As discussed by Johnstone and Hielscher (2017), chirp facilitates data exchange, aids in location determination, and enhances communication and coordination within mining operations. Mining companies worldwide are investing in the digital transformation of their operations aligning with the observations of Liu et al. (2016).

3 Technology adoption coal mining

3.1 Mining 4.0 technologies

- ❖ **Cloud mining**— It integrates the core business of the mine such as production and operation mgt, mining technology, planning services into cloud through effective use of cloud technology, cloud resources and cloud services.
- ❖ **Artificial intelligence**- Artificial Intelligence (AI) is revolutionizing coal mining by optimizing operations, enhancing safety, and improving efficiency. Through advanced algorithms and machine learning techniques, AI systems analyze vast amounts of data collected from sensors, drones, and other IoT devices to predict equipment failures, streamline logistics, and optimize resource extraction.
- ❖ **Internet of things**-It enables things equipped with RFID sensors, actuators and mobile devices to interact with each other and work collaborate towards reaching a common goals.
- ❖ **Drone**— Drone is used for 3D Mapping of mine environment, quality control of drilling and blasting, state of coal deposit and monitoring the sustainability of tailing

- ❖ **Virtual Reality-** VR is generated by software and audio visual transmission. It is about the recreation of aspect of real life in these recreations, users feel inside them. The usefulness lies in possibility of performing simulation and education.
- ❖ **Augmented Reality-** It allows remote inspection and assistance by experts who are remote to machinery, equipment, processing plants among others. It is also possible to carryout maintenance and repairs assisted by experts who remotely guide less experienced personnel in carrying out what is necessary step by step.
- ❖ **Intelligent logistic system-** An intelligent logistic system in coal mining integrates cutting-edge technologies to streamline operations and optimize efficiency throughout the supply chain. Utilizing advanced algorithms and real-time data analytics, it coordinates the movement of materials, equipment, and personnel seamlessly, enhancing productivity and safety. Automated processes such as predictive maintenance for machinery and dynamic routing for transportation ensure minimal downtime and maximum resource utilization.
- ❖ **Machine vision**—Machine vision opens up new ways to automate mining enterprises that are being upgraded to Mining 4.0 platform by integrating traditional mining equipment and robotics, traditional human decision making and their adjustment by machine to optimize processes.
- ❖ **Remote sensing-** Remote sensing is very useful for topographical survey of mine and mining operation, measurement of progress of operations, blasting, slope monitoring, inspection of dump and deposits, transportation of tolls and artifacts as well security inspection.
- ❖ **Enterprise Resource planning (ERP)** - It is designed to integrate and efficiently employ all of organizational resources. There is a connection with big data. By

employing ERP, real time data can be evaluated and allow for early detection.

4. Case Study

The chosen case study revolves around a prominent coal company in India which holds a significant position ,meeting a substantial portion of the country's coal demand.

1. *Monitoring of vehicle movement-* The coal is dispatched to consumer through rail, road, and merry go round and conveyer belt. The coal is transported from mine to railway siding by trucks and by conveyer belt to silos for dispatch through rail. All the trucks have been fitted with GPS sensors and their movements are tracked from control room. This has increased the effectiveness in the system. Earlier for monitoring of vehicle movement , a large number of manpower was engaged. The monitoring by using GPS has resulted in lesser deployment of manpower.
2. *Geo fencing of mine boundary and designated routes— Geo fencing of mine boundary has been done to restrict entry and exit of unauthorised vehicle, coal carrying trucks. In case of any encroachment, signals are generated to make the concerned persons alert and for taking suitable real-time action. The mine has been able to control the pilferage of coal and other consumables.*
3. *Freight Operations Information system (FOIS) connectivity – It has been installed in different railway sidings for transferring weighment data from in-motion rail weigh bridge instantly to railway server in coordination with railway. This is a tamper proof system of weighment and data transfer. The mine has been able to reduing the loading time and turn around time.*
4. *CCTV surveillance-* CCTV have been installed at coal stocks, weigh bridges, mine

entry-exit barrier, railway siding, explosive magazine, coal sampling/crushing points for e-surveillance. Now, the man-power and person requirement of the PQR company for performing this work has reduced and due to this OMS of the mine has increased.

5. *Deployment of high capacity HEMM*—The mines used to deploy lower capacity dumpers of 50/60 Te capacity and now is deploying 240 Te dumpers which is capable of moving larger volume of coal/OB in comparison to previously used dumpers. This has drastically reduced the deployment of dumper operators. Similarly, the company has deployed 42 M3 shovels and 381 mm drills for faster evacuation of coal an OB with lesser manpower, lesser fuel/power consumption and increased safety.
6. The mine has deployed in-pit crushing and carrying of coal by belt substantially which has reduced deployment of dumpers.as increased he safety of man and machine.
7. Establishment of Control and command Centre—The company has established control and command centre at its corporate HQ and production areas for real time monitoring and control of activities. This has reduced the deployment of manpower substantially.
8. Implementation of SAP/ERP- The company has implemented SAP/ERP and integrated all its activities viz finance, HR, Material, project and others.

5. Results and Conclusions

After introduction of the technology , the mine has been able to increase production, productivity and reduce accidents. The morale of the employees have also gone high.

After introduction of latest technology, following Jobs are likely to see significant increases

- Drone Operators (short term)
- Industrial Internet of Things (IIoT) sensor design (mineral identification, environmental monitoring, etc.)
- Highly skilled Maintenance Techs
- Network Administrators

- System Integrators
- Algorithms for planning, routing, traffic management, blend optimization
- Analytics and Reporting

The company is likely to face shortage of skilled manpower in near future and company must gear up to meet this shortages.

5. Future Trend

Automation of mining operations reduces cost, increase safety and productivity. There will be heavy reliance on remotely controlled HEMMs like excavator, dumpers, dozers, drills by employing location awareness, Artificial intelligence, machine learning.

The use of sensors and IoT technologies to monitor machines and equipment facilitates automatic stopping if necessary to prevent accidents. Workforce of the future mines should have knowledge in computer science and engineering, statistics, coding, managing database, system integration, analytics, data visualization, hard-core math (AI/ML), etc. will be the skills most probably appreciated in future mining industry. This is a perfect instance of new jobs that will be created due to mine digitization and automation. The miner would be able to solve problems directly at the source by remotely interacting with other operators, experts, and customers in multi-competent teams.

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