Intelligent Enterprise with Industry 4.0 for Mining Industry

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Abstract. The mining industry is under transformation as digital and automated technologies transform the traditional process of extracting ore from rock. With high global demand of raw materials, reduced ore grades, stringent environmental legislation and less profit margin, the mining industry has to improve its productivity through smart mining to survive in the competitive market.

In smart mining, it is imperative to have a real-time flow of information between enterprise level systems and shop floor systems through application such as ERP. A mining company needs instantaneous visibility on production, quality, cycle times, machine status, and other variables in order to achieve optimum operations which necessitates intelligent enterprise with industry 4.0.

Industry 4.0 technologies provide deeper understanding of resource base, optimization of material and equipment flow, improved anticipation of failure, increased automation such as automated surveying using drones and 3D laser technology, automated drills, automated mobile fleets using fleet management system, automated plants. It also helps in monitoring real time performance vs plan and safety of men and machineries. By using Internet of Things (IoT), Big data, Machine to Machine (M2M), data analytics, intelligent sensors, robotics, drone the smart mining will be up graded with industry 4.0 in mining activities such as surveying, drilling, blasting, excavation. Haulage, processing and transportation.

The orientation of the paper revolves around various action plan for intelligent enterprise with industry 4.0 for improving their productivity to become more competitive globally.

Keywords: Internet of Things · Big Data · Mining · Operation research

1 Introduction

In today's competitive world the mining industry has to shift focus from production to productivity to survive. The boom and bust cycle of mining has been the same for decades, productivity has not improved rather declined over the decades. In this context, need of the hour is intelligent enterprise with industry 4.0 which have the power to unlock new ways of improving the productivity through the large-scale adoption of modern technologies. Intelligent enterprises have broad horizons with long-term perspectives. The enterprise can be intelligent in two ways. It can behave intelligently, or it can utilize "intelligence," to achieve its goals. The embedding of sensors in machinery

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to collect data and enable communications between machines is increasingly affordable and accessible.

1.1 Present Mining Technology

Fully mechanized mining operations have increased production and productivity in comparison to semi-mechanized and manual mining but to remain competitive productivity and standard of safety is to be increased many fold.

1.2 Challenges with Present Mining Technology

The present mining technology talks about physical entity, repetitive job, less productivity, less safety of men and machineries, less automation, less data analysis etc.

2 Need of the Hour- Intelligent Enterprise with Industry 4.0

Mining companies generate vast amounts of data, and extracting relevant data about machinery, processes and ore bodies is now more important than ever before. Complex mining tasks such as geo-modeling, day-to-day scheduling and predictive maintenance are increasingly handled by smart analytics software packages, while smart phones and other handheld devices have transformed the way that workers interact not only with each other but with machines. Work clothing can also incorporate sensors that transmit employee locations and trigger warnings about hazardous situations, improving safety standards.

Advances in robotics and sensor technology are also now making guided equipment much more affordable and effective. The use of tele-remote, assisted control and fully autonomous equipment is becoming increasingly widespread in the mining industry.

These technologies will enable a fundamental shift in the way we mine. There will be reduced variability in decision-making and more centralised automated operations that reduce variability in execution. Through a better understanding of the resource base, knowing exactly what is in the ground and integrating geological information into one universal database enables operators to optimize drilling and blasting operation, creates better mine plans and helps avoid resource quality issues. Deploying remote-controlled machinery such as Unmanned Ariel Vehicles (UAV) or underground vehicles with laser scanning technologies can cause a change in productivity, and the 3D modelling data provided by these machines can inform engineers in remote locations and avoid sending manpower to unsecured mine faces.

Real-time data and better analysis tools also make possible improved scheduling and processing decisions, while fitting smart sensors to equipment facilitates the prediction of failure of components.

2.1 Industry 4.0

The first industrial revolution used water and steam to mechanize production, the second used electric energy to create mass production and the third used electronics and information technology to automate production. Today a fourth industrial revolution builds upon the third revolution and the digital revolution that has been taking place since the middle of the last century. This fourth revolution is characterized by merging technology that synthesizes the lines between the physical, digital and biological spheres to completely uproot industries all over the world. The extent and depth of these changes are a sign of transformations to entire production, management and governance systems.

The fourth industrial revolution "Industry 4.0" is with big data, machine to machine connectivity and automation. The current level of innovation and strategic partnerships within the mining technology space demonstrates the agility of businesses for the future of the industry.

The genesis of industry 4.0 rests with the emergence of the **Internet** which is the mother of digitalization. This digitalization enables us to build a new **virtual world** from which we can steer the physical world.

The industry of today and tomorrow aim to connect all production means to enable their interaction in real time. **Factories 4.0** make communication among the different players and connected objects in a production line possible due to technology such as **Cloud**, Big Data Analytics and the Internet of Things.

The applications for the industrial sector are already enormous: predictive maintenance, improved decision-making in real time, anticipating inventory based on production, improved coordination among jobs, etc. Day after day, all these improvements are gradually optimizing production tools and revealing endless possibilities for the future of industry 4.0 at crossroads for an interconnected global system.

Industry 4.0 could be the first to deviate from the energy grid trend in terms of non-renewable resources because it has been integrating more and more possibilities to power production processes with alternative resources.

2.2 Big Data

In each organization, a vast amount of data is generated that contains various information from internal and external sources such as data transactions, corporate documents, social media, sensors and other devices. Companies can take advantage of analyzing their data to satisfy customer needs, optimize their operations or obtain new sources of revenue. Big Data encourages the analysts to take the complexity and diversity of the world into consideration when they examine the data sets instead of endeavoring to reach punctual and perfectly accurate results from analyses made in an artificial and controlled environment.

Four dimensions need to be considered to get value out of big data: volume, velocity, validity and value. Volume is the amount of data. To gain insight from this mass of data, special tools are required. Velocity means that data does not have a stable state, but it is always changing, and new data is generated and transferred in a matter of milliseconds. Validity means that whether data is correct and accurate for the intended

use. Value refers to the outcome, the value that can be extracted from the data sources with big data analysis.

Machine data is generated in every industry from healthcare equipment through handheld devices to industrial machines, and they can be used to find patterns and clusters or to predict trends. It has several business use cases, such as performance analysis, root-cause analysis, predictions etc.

2.3 Data Analytics

Big Data Analytics is now a big blip on the radar of the Mining industry. Big Data Analytics would spur the next wave of efficiency gains in ore extraction, analysis, transportation and processing by enabling faster and better informed decisions at all levels.

In a competitive market, every effort to improve margins using operational intelligence is necessary. That is why analytics is expected to play a major role in driving better asset utilization, boost productivity, and address material flow delays. Helping achieve this goal are sensors embedded across mining operations. These sensors are generating vast amounts of geo scientific, asset condition and operational data in real time. Improvements in internet speeds are enabling real-time collection of data from the extraction point right up to the final transportation of ore to plants. This data can be analyzed using massively parallel processing and faster distribution of intelligence. It is possible to do this because modern Big Data platforms can assimilate vast amounts of heterogeneous, real-time inputs from multiple sources. These, in turn, extract real-time predictive and prescriptive analytics to drive operational excellence.

Intervention Across Mining Processes: Material process flow plays a big role in the mining value chain. This includes analyzing impact of unscheduled events owing to mechanical breakdowns Dumpers, shovels and critical transportation medium, queuing time, and such overheads. There are a number of other causal variables that can be analyzed for impact on production throughput on a daily/monthly basis using techniques such as Machine Learning, Continuous Pattern Matching and Statistical Predictive Model.

Big Data Analytics Platform, equipped with these models, can leverage the value, volume, velocity and variability of data, delivering several benefits across extraction, intermediate transportation and final transport to plants.

2.4 Application of Big Data Analytics in Mining Process Through Operation Research:

Different operation research techniques are available to achieve this objective [1].

- Queuing model for transport system
- Markov Model for maintenance system.
- Reliability model for production system and equipment performance

The Mining industry can derive several critical business benefits from Big Data Analytics. These include:

- Ensuring continuous flow of material from ore extraction point to the processing plant
- Maximizing ores hauled by optimizing bottlenecks in production
- Reducing non-productive time between unit operations such as unscheduled maintenance, delays, wastage and waiting time
- Helping management make informed decisions on the "as-is" production process, covering the value chain from extraction to delivery at plants and beyond
- Providing on-line assay results and interpretation analysis to field geologists to take informed decisions

2.5 Internet of Things (IoT)

The Internet of Things (IoT) is the connection of objects such as computing machines, embedded devices, equipment, appliances, and sensors to the Internet. This emerging network technology can potentially transform the mining industry by creating new ways of maintaining mine safety and improving productivity. The technology involves connecting equipment, fleets, and people based on radio frequency identification device (RFID) and sensor technologies [2].

How can IoT help the mining industry:

1. **Automate maintenance and operations of machines** – Leads to creation of newer collaboration models with OEMs for monitoring via cloud connectivity and networks.
2. **Standardize processes** – Helps build newer business models and highly agile processes at the operations level.
3. **Improve traceability and visibility** – Lets users automatically transfer and receive data over a network without requiring human intervention. Moreover, remote monitoring of operations ensures maximum efficiency, improved safety, decreased variability, and better identification of performance issues.
4. **Ensure safety of people and equipment** – Integrates mine automation system with automated physical elements to create a real-time, multi-dimensional model from a variety of data sources including the sensors on equipment as well as geological and other data. The system can then be used to optimize and coordinate the mine's layout, operation, and vehicle paths to ensure high efficiency and safety.
5. **Move from preventive to predictive maintenance** – Prevents equipment failure using machine to machine sensors that can detect the status of the equipment (like temperature, pressure, vibration, speed), collect maintenance history, and determine external weather conditions. Provides analytics to predict failures before they occur, giving the ability to react at the right time. Spare parts can also be ordered well in advance and procurement of machines can be based on Life Cycle Cost analysis.
6. **Get real-time data and analytics** – Uses tools to provide 3D displays of the mine and other related data for use by pit controllers, geologists, drilling/blasting teams, mine planners, and supervisors. Mining vehicles have built-in sensors to measure oil temperature, contamination, tire pressure, bearing rotation, vibration, frame rack, bias and pitch, engine speed, and brake pressure. The data is transmitted remotely and used to recommend maintenance schedules and alert teams about potential trouble before it takes place.

Current IoT Usage
The opportunity to visit operation center of Rio Tinto at Perth, Australia where mining majors like Rio Tinto and BHP Billiton have set up their integrated remote operations centers for monitoring operations in the iron ore mines of Pilbara, about 1,500 km away. Rio Tinto also opened a processing excellence center in Brisbane to monitor and analyze the processing data in real time from seven of its operations in Mongolia, the United States, and Australia with the help of huge, interactive screens. From the data collected, a team of experts in mineral processing suggests solutions for optimizing mineral processing at these seven sites.

Leveraging IoT to Drive Bottom-Line Growth
The IoT-led journey towards business transformation in mining has just begun. By making mining safer, more efficient, and more automated, IoT is making mining jobs more high tech and allowing people to work remotely, with fewer workers in hazardous roles at the mine site.

3 Summary

Slow to change and reluctant to address the economic, environmental, and safety impacts, the mining industry has been struggling to keep up with the ever-progressing technological world. If it does not embrace the fast-advancing technical developments seen today, it will quickly lose its standing in this world of regulations and competition. To survive in this competitive environment, every effort to improve margins using operational intelligence is imperative. That is why Intelligent Enterprise with Industry 4.0 is expected to play a major role in driving better asset utilization, boost productivity, address material flow delays and helps mining industry to survive in the comimg era.

This is the beginning of new era in mining industry; we have to go a long way ahead.

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