Industrial Internet Applications in Mining Industry

Mining differs from other industries in many ways.

1. **Uncertainty**: Product variability and safety conditions depending on location of the operation within a mine. This uncertainty becomes greater in underground as against open cast mines.
2. **Frequent equipment breakdowns**: Mining equipment exposed to extreme and variable weather conditions and strains and stresses on them by rocks of unpredictable size and hardness result in frequent breakdowns.
3. **Hazardous conditions**: Fire, flood, collapse, release or explosion of toxic gases and accidents during use of explosives are some of the most critical hazards, particularly in underground mining.

With advancements made in augmented and virtual reality, sensor technology, analytics and AI, mining industry today has the opportunity to reduce uncertainty, reduce frequency of equipment failures and vastly improve safety conditions of miners.

This paper discusses the role of Industrial Internet of Things (aka Industrial Internet), specifically monitoring and analyzing data gathered from use of different categories of intelligent controllers in machines and environment monitoring sensors in mining operations. Monitoring of course includes sending of alerts whenever a threshold level is breached or there's significant deviation from the normal. Industrial Internet is shaping Mining 4.0 in reducing Equipment Failures and Catastrophic Accidents. (This Paper excludes the role of Virtual Reality, a technology that is helping to simulate actual mining conditions, thereby reducing "uncertainty" factors).

Reducing Equipment Failures

Here's the statistics on Equipment Failures, measured by "Overall Equipmment Effectiveness (OEE)[1]." A recent survvey by McKinsey indicates a global average OEE performance of 27 percent for underground mining, 39 percent for open-cast mining and 69 percent for crushing and grinding—compared with 88 percent for upstream oil and gas, 90 percent for steel, and 92 percent for oil refining. There obviously remains significant untapped potential for productivity improvement.

Improving OEE is a key consideration in GFS Industrial Internet Solutions for Manufacturing and Resource Industries. As modern equipment are equipped with sensors or intelligent controllers, they lend themselves to active monitoring by an Industrial Internet application like GFS Crane. Active Monitoring would yield:

a. Alerts based on threshholds set for different operating parameters. Outcome: improvement in Availability ratio[1] of OEE.
b. Actual Performance versus Plan (Deviations from Normal): GFS Crane Asset Management, combined with active monitoring, helps us know the state and location of every piece of equipment - and, whether it is operating according to or outside of the plan. This insight focuses on variability and compliance to plan and moves control to a more sophisticated decision-making capability at the center that can take actions to optimize operations across the entire supply chain of mining operations, rather than local silos. Outcome: Improvements in Performance & Quality ratios[1] of OEE.
c. Failure Analytics: Historical data which can be analyzed via correlation of failures (or drop in machine performance) with events (like size of rocks) and environmental conditions (weather, age of machine). Outcome: Improvement in Availability ratio.
d. While (a) and (c) primarily improves Availability ratio in OEE equation[1], and (b) provides positive impacts on Performance and Quality, future road map envisages machine learning on operating data to predict failures well before any alerts are generated and prescriptive analytics to dramatically improve Performance and Quality ratios.

Acting on Alerts and **Failure Analytics** for each machine category would help design a solution to (a) improve MTTR and (b) determine optimal EOQ and spares inventory for each category per location.

Failure Analytics will have the following:

- Relationship map (called a Device Chain) of all sub-assemblies and components (parts) of a machine that defines the interdependencies
- A computing unit called Fault Analyzer (FA): based on sensor data, failures of components are analyzed and tracked. Historical data on failure rates of every relevant component would enable stocking spare parts adequately. In addition, the system would flag component suppliers with higher rates of failures.

Eliminating Catatrophic Accidents

Gas sensing technology plays a significant role in the safety of mining industry. Improvements in hazardous gas monitoring systems can reduce the risks in mines, save countless lives and prevent damage to the property. The sensors should address the safety concerns created by flammable and toxic gases and depleted oxygen levels under harsh mine conditions, where extreme temperature changes, rapid humidity variations and significant pressure fluctuations are experienced. Currently, pellistors[2] are utilized on the walls and machinery in mines to detect any hazardous gases. However, there are drawbacks[3] in their use. To address them, the idea of using UV-LED activated gas sensors is gaining traction.

The UV-LED activated sensors:

- are small, have instant on/off operation, are environmentally friendly, operate with significantly low energy and have a long lifetime with self-cleaning specifications.
- provide selective sensing and offers the possibility of being configured in a matrix arrangement to fit different measuring environments
- have the potential to transform the entire spectrum of current sensors in mines to small wearable gas monitoring systems with fast and sensitive detection.

We are starting to see work clothing of miners that incorporates sensors transmitting data to managers about hazardous conditions, improving safety outcomes.

These modern sensors can be actively monitored by an Industrial Internet application like GFS Crane. Applications would be similar to what's enumerated under Reducing Equipment Failures, but now focussed on Safety, such as:

a. Alerts (breach of threshold levels) to help take timely actions before emergency situation develops
b. Deviations from Normal: This capability can be deployed to improve safety outcomes by detecting deviations from expected operating conditions
c. Analytics: Based on historical data collected from the senors as well as machines, and correlation of events in the mine, one can get insights to prevent mishaps.
d. Machine Learning (future road map): This technology that works on current operating data rather than historical, can dramatically alter the safety outcomes of mines in the future. Introduction of robotics where rock collapse or flooding are high possibilities is another alternative being considered in advanced minining technologies.

GFS Crane is a vendor-neutral Industrial IoT application developed by GreenField Software.

- ❖ Provides advanced monitoring, analytics and management capabilities for mission critical physical infrastructure systems
- ❖ Supports multiple protocols to connect with heterogeneous devices & sensors
- ❖ Provides centralized automated monitoring, control & management of distributed facilities of manufacturing plants, mines, telecom towers, buildings and smart cities.

GFS Crane is built for customers with distributed capital-intensive infrastructure. The common business purpose served by GFS Crane across all these verticals are:

- Mitigating risks of failures of a site infrastructure
- Reducing operating costs through improved energy efficiency and higher productivity
- Controlling capital costs through better capacity planning and asset management
- Maintaining highest levels of security of the site infrastructure.

GFS Advantage

Promoted by an industrial engineering group from Kolkata, GFS leadership comprise of industry veterans from Oracle and Siemens. Our customers span across South Asia and Europe from diverse verticals: Automotive, Financial Services, Government, Media, Oil & Gas, Power Utilities and Technology.

For more details, please visit http://www.greenfieldsoft.com or write to sales@greenfieldsoft.com

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Notes:

1. Overall Equipment Effectiveness = Availability x Performance x Quality, where
    a. Availability = Operating Time/Scheduled Time
    b. Performance = (Parts Produced x Ideal Cycle Time)/Operating Time
    c. Quality = (Units Produced – Defective Units)/ (Units Produced)
2. Pellistor: A solid state device used to detect gases which are either combustible or which have a significant difference in thermal conductivity to that of air.
3. Drawbacks of Pellistors: Pellistors utilize the change in resistivity for various pollutant and toxic gases detection, which is followed by the reaction between the sensing layer and gas components. A drawback of a conventional pellistor is the high operating temperature (200°C to 500°C) originating from the need for producing a measurable baseline resistance. The high operating temperature induces high power consumption and a relatively high cost of the system due to the design complexities. It also lowers the stability and useful lifetime of the sensor. Besides, the relatively long time to reach the target temperature can literally prove to be fatal.