BIG DATA FROM BIG MACHINES

A METHOD FOR IMPROVING THE USE OF DATA FROM MOBILE MACHINES IN POTASH AND ROCK SALT MINING

Dr. Stefan Höntzsch, Guido Wolters, Dr. Felix Straßburger, Manuel Vargas Nettelstroth, Artem Zitzer

The increasing digitization of all aspects of public life provides significant opportunities and potential for mining. K+S Aktiengesellschaft is leveraging this potential in a variety of initiatives both on surface and underground.

A major focus is on the sustainable and effective utilization of existing machinery, particularly in terms of improving productivity and operating time while minimizing unscheduled downtime and optimizing maintenance planning.

In the areas of production and maintenance, deploying machine-generated signals and error notifications has tremendous potential value. Targeted use of machine data allows for real-time fleet condition monitoring, predictive maintenance planning, and spare parts management, which can reduce downtime and increase long-term productivity. Furthermore, it can also help identify the possible need for staff training and recognize and prevent misuse of machinery.

Translated by Svetlana Agalakova

SMART MACHINE DATA USE AT K+S

In a pilot project, K+S Aktiengesellschaft has installed data loggers from talpasolutions GmbH onto 150 vehicles, including load-haul-dumpers (LHDs) and scalers from GHH Fahrzeuge GmbH, in order to generate tangible and relevant insights from machine data.

The raw machine data and errors are transmitted to decentralized cloud storage via WLAN. Algorithms in the cloud analyze, filter, and process the stored data before converting it into pre-defined key performance indicators (KPIs).

KPIs as well as selected, relevant error notifications can be displayed and analyzed in configurable dashboards.

Dashboards can also be pre-configured and shared among stakeholders at different levels (e.g., maintenance and production, shift foreman level, operation engineers, and production managers).

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TALPA

REQUIREMENTS FOR UTILIZING BIG DATA IN UNDERGROUND MINING

In order to collect, transmit, and analyze enormous amounts of data underground, K+S mines require a wide area network of WLAN access points. To ensure rapid, uninterrupted, and timely data transmission, access points are located at every feeder breaker and maintenance site. After the planned installation of Access Points at fuelling stations, data may also be accessible from vehicles that do not frequently visit feeder breakers or maintenance sites, such as auxiliary machines. The objective is to retrieve data from each vehicle regularly, at least once a day, and save it in the cloud. It is also required to have access points on main routes and at mine area entrances and exits in order to assign machinery to specified mine dirsticts, as this is the only means of guaranteeing inter-area activity, such as operating vehicles.Talpacortex U data loggers from talpasolutions are installed on the machine alongside the antenna and connected to the vehicle's CAN-bus ports.

The data logger has an internal 32 GB memory and transfers data to the access point at a rate of 3 MB/s on average (at longer distances and in real mining conditions, the speed can potentially reach 72 MB/s, while 10 to 25 MB/s is realistic). The data is uploaded in log files, which are 6MB in size. The log file contains data for a maximum of ten minutes of machine activity. An internal diagnostic and monitoring tool is used to monitor data logger activity and conditions. In the event of a network outage, the data may be manually downloaded via the built-in interface.

TURNING BIG DATA INTO SMART DATA

MAINTENANCE

The GHH Fahrzeuge mining machines used by K+S send between 900 and 1,400 signals to the connected data loggers through the CAN bus. About 500 of these signals are error and warning messages. However, the use of unprocessed machine data ("Big Data") is not beneficial, as without intelligent processing, filtering, analysis, and presentation of the relevant data ("Smart Data"), concrete insights and the resulting action recommendations would be lost in the multitude of raw data.

In terms of maintenance, the errors and warnings registered on the vehicles are of interest, but it is of more importance, which of them might cause short-, medium-, and long-term damage to the vehicles. Along with the vehicle manufacturer, a priority matrix was used to pick and assess the severity of relevant faults.

The primary concerns were therefore:

1. **What errors occur?**
2. **Are these errors directly related to the machine's maintenance and health?**
3. **Which personnel must be notified of these errors?**
4. **When do errors occur?**
5. **What is the duration of which message?**
6. **Which signals are associated with the errors?**

Thus, it has been identified that out of about 500 error and warning messages, less than 20 were associated with a significant portion of the relevant machine damage. The next step is to visualize these issues for specific user groups and provide them with a notification function based on the severity of the errors. In order to specifically target maintenance staff, the severity of the error, a detailed error description, concrete recommendations for action, as well as relevant statistics and associated signals, should then be provided in a context menu. When this data is combined with the number of the machine´s engine hours, a decision may be made on whether the issue should be addressed immediately or during the next scheduled maintenance.

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PRODUCTION

In contrast to the maintenance area, the production area prioritizes the utilization of data to maximize the productivity and efficiency of the machines. Important pre-defined KPIs here are: the tonnage moved per shift, the tonnage per cycle, the cycle duration, the degree of utilization, or the payload performance. They are registered for various time intervals (for example, hour, shift, day, week) and may thus be compared between individual machines, machine groups, or mining areas. Validated data, i.e. data that has been compared with the signals generated and the actions performed, is required for the correct determination of the key indicators. It is also critical to distinguish between secondary activities (for example, clearing the route, trips to the maintenance site, and refueling, etc.) and productivity cycles (mucking, tramming, unloading, driving to the blasted area).

To be able to ensure this, so-called validation shifts of vehicles of different types and categories are performed. A video camera (GoPro type) is fixed on the vehicle with a magnet in the working direction (either in the direction of the bucket or the scaler arm) for this purpose. When the time between the camera and the vehicle is aligned, an employee performs a normal shift, which is recorded by the camera. An AI-based algorithm is used to perform the alignment and analysis of the actions/machine activities, as well as their comparison with the signals.

PAYLOAD MEASUREMENT

In the production area, it is essential to estimate the tonnage in the LHD bucket as precisely as possible, as this provides information on shift and production area. Furthermore, the estimated tonnage values may be compared to the measured tonnage estimation values on the belts (using belt scales). Currently, tonnage estimation in loading vehicles is done manually using a payload measurement (PLM) system integrated into the vehicles. In turn, the mode of operation is determined by the kinematics of the GHH loading vehicles (Z and T kinematics). While changing hydraulic components on the vehicles, the calibration of the PLM function must be performed if necessary. Depending on the design, the general method of bucket weighing is either semi-automatic or manual. The vehicle must be stationary for a few seconds with the bucket filled. This results in a brief interruption of the tramming cycle. Following a short pressure surge, the bucket oscillates for a few seconds before reaching a plateau that indicates the measured value for the tonnage in the bucket.

The goal is to eventually automate the estimation of tonnage in the bucket and save the time now required by halting a tramming cycle for weighing. The pressures in the bucket's hydraulic cylinders during a cycle (loading, full trip, unloading, empty trip) have to be compared. The tonnage is then estimated using a calculated factor and the pressure difference between the full bucket and the empty bucket during the loaded and return cycles.

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DATA VISUALIZATION IN PRECONFIGURED PERSONA-SPECIFIC OR FULLY CUSTOMIZABLE DASHBOARDS

To make the generated "smart" data useable, it must be made accessible and visible for relevant groups of stakeholders on an ongoing, timely, and regular basis. GHH inSiTE, the tool developed for this purpose, combines preconfigured dashboards for various hierarchical levels with fully customized dashboards to which any key metrics may be added using widgets.

Persona interviews were conducted in advance at the different K+S sites in order to provide employees from specified levels of expertise with data and key metrics that are solely relevant to them. During these interviews, questions concerning the data, key metrics, and workflows important to the respective hierarchical levels were asked, the daily work routine was clarified, and the potential added value of the data was assessed. These distinctions are reflected in various preconfigured dashboards that specific groups (or hierarchical levels) will utilize.

The following are significant distinctions between the different persona-specific dashboards:

1. **the metric's level of detail**
2. **the metric's degree of complexity**
3. **the key metrics' comparability with other areas** (Production area vs Entire mine)
4. **the number of machines.**

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SUMMARY

The K+S Aktiengesellschaft pilot project on the use of machine data in mines demonstrates that smart machine data may contribute to more efficient and sustainable mining in the medium to long term. In this context, it is critical that raw signals and machine faults be reviewed, filtered, and analyzed in order to deliver needs-based information tailored to the operation's distinct hierarchical levels.

Data validation, or the comparison of machine signals with the activities performed, is crucially important in the production since it is the only method to assure proper classification of productive cycles and secondary activity. Validation using video recordings has proven useful in this situation. The estimation of the transported tonnage per cycle (travel), which will be carried out automatically in the dynamic cycle via the pressure of the hydraulic cylinders of the kinematic systems, is of special relevance.

For the maintenance area, the targeted evaluation and display of machine data creates an additional monitoring tool for maintenance planning as well as timely troubleshooting of malfunctions and failures. As in the production area, a network of WLAN access points covering the entire area is required so that machine data can be transmitted on a regular, timely, and up-to-date basis, and the response time from defect message to problem rectification can be decreased.
Smart machine data should enable predictive maintenance in K+S mines in the medium to long term, contributing to a continuous improvement process.
Additionally, the utilization of machine data should promote proactive employee training by detecting and correcting operational misuse.

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