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A Variable Test Bench for Sustainable Mining

How Liebherr Reduces Development Time for Its BEV Mining Trucks

imc Test & Measurement
Application Note

APPLICATION NOTE

Electric drives for “zero emissions”

Liebherr, a German-Swiss multinational equipment manufacturer, is pursuing a conscious approach to the development of its mining trucks, focusing on electric and hybrid drives. From a business, technical, and regulatory perspective, this makes more and more sense. Mining companies are major CO_2 emitters and are striving to reduce or completely eliminate their greenhouse gas emissions with the help of alternative drives. Another objective of the mining industry is to produce CO2-neutral steel.
To offer solutions for decarbonizing the mining industry, Liebherr is developing, among other things, battery-electric mining trucks. These machines are designed to replace diesel-powered ones, thereby supporting the objective of a zero-emission strategy.

Demanding tests for harsh environments

Liebherr tests its innovative, sustainable drive systems for the mining industry at its own testing center. Here, the company implements rigorous testing methodologies for heavy-duty machinery, switchgear, energy storage systems, human-machine interfaces, IoT gateways, and customized control solutions. To ensure the reliability of components and interfaces used in mining, construction machinery, maritime cranes, and aviation, the testing center is equipped with specialized test benches designed for demanding environmental conditions, including vibration, salt spray, extreme temperatures, and mechanical stress.

Liebherr planned a test bench for a new battery-electric mining truck drive system with up to 6 MW system power and was advised by imc Test & Measurement on the selection of the measurement technology.

A 240-ton truck driven by electric power

A mining truck is a heavy-duty vehicle designed to carry a payload of up to 240 tons. The individual components of a mining truck are much larger than those of a passenger car. Therefore, the electric drive requires several megawatts of power to move the heavy machine in open-cast mining. Nevertheless, the weight must still be in optimal proportion to the vehicle's power.

Developing the individual components, such as the battery, is an innovation in itself. From a technical standpoint, the development, validation, and optimization of the drivetrain are extremely challenging because of the interaction of the traction battery, battery cooling, control units, and drive motors in the overall system.

One challenge is managing heat to prevent overheating and ensure the components' service life. Robust power electronics are necessary for reliably and efficiently handling high voltages and currents in the megawatt range. Additionally, the powertrain must be seamlessly integrated into the heavy-duty machine's architecture and designed to withstand the harsh mine environment, where vibrations, dust, and road debris can affect the vehicle.

A test bench of superlatives

The test bench must be designed to handle drivetrain performance levels up to ten times higher than those of conventional systems. The hall built specifically for the test bench has an area of approximately 9700 ft². Another notable feature is the adaptability of the test hardware to different test scenarios, allowing for comprehensive component testing.

Fig. 1.
The new teststand facility

"When planning and developing a test bench of this size, we rely on the support of our partners. By involving imc early in the planning phase and taking advantage of their expertise in selecting the appropriate measurement systems, we were able to implement a solution that reliably acquires all necessary measurement data and enables control of the test bench.
In addition to the option of integrating third-party systems, the system offers the flexibility needed to respond to constantly changing test tasks."
— Felix Lukasch
Head of Test Center Systems and Field Measurements
Liebherr-Electronics and Drives GmbH

The powertrain of the mining truck will be tested in accordance with the following procedures:

- Validation of the main powertrain with 2 MW of power at various voltage levels up to 3500 V.
- Validation of the auxiliary power supply up to 500 kW at 700 V.
- Thermal validation of the air cooling system with air flow rates up to 4 m³/s, whereby the supply air can be preheated to 131°F.
- Testing of various water cooling systems is underway. Each system has a cooling capacity of 500 kW and a heating capacity of over 100 kW.

Due to the size of the truck components and the various tests, a decentralized measurement data acquisition system is required. This system must be close to the sensor and have a high number of channels and various bus interfaces. On the test bench, approximately 240 analog channels are measured. Including the channels recorded via CAN, approximately 900 channels are recorded and monitored on the test bench. For this reason, an imc measurement system with a flexible, modular design was chosen. It can be adapted to changing test applications at any time.

The high electromagnetic compatibility (EMC) load also requires decentralized measurement data acquisition to digitize the measurement data close to the measuring point. For this reason, non-conductive glass fiber sensors are used for temperature measurement in the electric powertrain. These sensors ensure the most reliable, precise measurement results in the high-voltage environment.

Fig. 2
View of the test bench

Measurement technology enables flexible testing applications

When developing the powertrain test bench, the focus was not only on the requirement to implement high-precision electrical power measurement for tests in a high-voltage environment, but also on maximum flexibility of the measurement solution and cost-optimized equipment.

The test bench is equipped with imc measurement hardware and imc software and consists of the following systems:

- The central rack contains an imc CRONOS*compact* measurement system.
- The imc CRONOS*flex* and imc CANSAS*flex* series offer a range of measurement modules designed for decentralized measurement data acquisition, with a focus on proximity to the measurement points.
- A third-party system for power measurement.
- The imc STUDIO measurement software facilitates the control of the test bench.

Fig. 3.
View of the control room – teststand control with imc STUDIO.

Accelerated development of new drive technologies

With the implementation of the test bench for the new electric mining truck, Liebherr can now thoroughly test and validate its innovative drive systems as a fully integrated system. The expanded testing capabilities deliver comprehensive measurement data across the entire electric drivetrain—from the energy source onward—enabling Liebherr to significantly reduce development and optimization times both on the test bench and in field operation at customer sites.