

Toromocho – A giant in high-altitude mining

ABB is delivering mine-wide electrical and process control solutions - and the most powerful gearless mill drive systems ever made - at the world's highest altitude mining project: the 4,700 m Toromocho copper mine in Peru.

Toromocho Mountain is one of the world's largest untapped sources of high-quality copper. It is also one of the highest. Located among the peaks of the Andes at an altitude of 4,700 meters above sea level (masl), Toromocho is a pioneering attempt to raise the bar in high-altitude commercial mining.

Toromocho is situated about 140 kilometers inland from the Peruvian capital, Lima, in the ore-rich mining district of Morococha in Junín Region. When production starts in late 2013, the mine will deliver 1 million tons of copper concentrate, 10,000 tons of molybdenum and 4 million ounces of silver oxide annually over a period of 32 years.

Toromocho is being developed by Minera Chinalco Peru, a subsidiary of Aluminum Corporation of China (Chinalco), one of the world's largest producers of alumina and primary aluminum. The engineering, procurement construction management (EPCM) contractor for the project is Jacobs Engineering.

Processing the ore at such a high altitude - and in an area subject to frequent seismic activity - places huge demands on the electrical and process equipment. It has to be exceptionally robust and reliable.

To ensure that these requirements were met, Chinalco and Jacobs Engineering selected ABB as a technology partner and principal supplier of the mine's electrical and automation equipment. They awarded ABB contracts worth around \$120 million to supply three gearless mill drive systems for the semi-autogenous (SAG) mill and two ball mills, a plant-wide electrical solution, and a process automation system to control the production process and integrate the mine's electrical, control and monitoring systems onto the same automation platform.

The world's most powerful gearless mill drives

The three gearless mill drive (GMD) systems are the ABB most powerful ever made. The GMD for the 40-foot SAG mill has a power rating of 28 megawatts (MW), and the GMDs for the two 28-foot ball mills have a power rating of 22 MW. They are the largest diameter and most powerful SAG and ball mills drive systems at the highest altitude installed to date. All three mills were supplied by FLSmidth.

ABB has extensive experience of designing GMDs with high power ratings for use at high altitudes of 4,000 masl or more. In fact ABB is already in the process of delivering a 28 MW gearless mill drive for the world's first 42-foot SAG mill - which will operate at an altitude of 4,200 masl - and has long had designs in place for 44-foot SAG mills with a rated power of up to 35 MW.

Gearless mill drive systems are an ABB innovation. They consist of a gearless motor, which is fed by a cycloconverter - an extremely compact and efficient drive system with several operating advantages, like variable speed and frozen charge protection. This innovative technology eliminates all critical mechanical components that are part of conventional mill drive systems, such as the ring gear, pinion, gearbox, coupling or air clutch, motor shaft and motor bearings. Eliminating such components increases the efficiency and the availability of the mill.

Designing GMDs with a 28 MW power rating for such large mills and for such a high altitude required ABB to solve a number of technical and logistical challenges.

For instance, ABB designed a new cooling system to dissipate the heat generated by the gearless motors at high altitudes – the largest motors ever installed in SAG and ball mills. Because of the altitude, the motor insulating material had to be optimized, tested and certified for operation in such demanding conditions. To ensure that the windings would cope with the stress of working at 4,700 masl, ABB tested them in a hypobaric chamber to simulate real-life operating conditions. In fact all the electrical products and GMD components manufactured by ABB for use at Toromocho were certified for use at the higher altitude of 5,000 meters above sea level.

Another engineering challenge was the three cycloconverters. Normally, the cycloconverter for a grinding mill would require a 6- or 12-pulse configuration. But for Toromocho a more powerful solution was necessary. To feed the SAG mill with 28 MW of power and achieve the required performance characteristics requires an 18-pulse configuration – the first time that such a powerful solution has been used in a mining application.

Design innovations like the 28 MW motor, the 18-pulse cycloconverter and the new cooling system have an impact on logistics. The motor and the cooling system in particular had to be designed in such a way that they could be transported on winding mountain roads and through numerous tunnels. The motors were shipped in four segments, each one 15 meters in length and weighing up to 130 tons. The huge cooling system also had to be transported in segments, small enough to pass through the restricted height clearance of the tunnels.

Other ABB design innovations for Toromocho include an airlock system to protect the three GMD E-houses from dust and maintain the correct air pressure inside. And each GMD motor is fitted with a large number of sensors and instruments in order to monitor the machines during operation. This provides the motors with better protection and, when combined with ABB's remote diagnostics service, is a powerful tool for preventive and predictive maintenance.

Mine-wide electrical solution

The second contract awarded to ABB by Chinalco and Jacobs Engineering was for a complete electrical solution for the entire mine processing area. ABB's scope of supply is vast. It includes 23 kV gas insulated switchgear, 4.16 kV switchgear with bus ducts and surge arresters, 380 V intelligent switchgear with motor control centers and bus ducts, distribution transformers, 28 unit substations of various ratings, 190 low voltage and 35 medium voltage variable speed drives, fault current limitation and arc fault protection, uninterruptible power supply, and system configuration. All the major electrical equipment is made by ABB.

The electrical equipment is housed in 12 prefabricated containerized and highly compact E-houses, which range in size from 42 m² to 387 m². Each E-house is designed to ensure staff safety and is equipped with all necessary protections, including an arc management system, pressurization, air lock, climate control, fire detection and fire withstand, alarms, and lightning protection. With the exception of one specially designed E-house for medium voltage drives, which was delivered from Europe, all the E-houses were assembled and factory-tested at ABB facilities in Lima.

Each item of electrical equipment is tested and certified for operation at 5,000 masl, which is 300 meters higher than Toromocho. There is no recognized international standard for equipment specifications for this altitude, so ABB had to set its own stringent requirements. These include compliance with seismic zone 3 requirements and increased electrical insulation due to the lower pressure and reduced cooling effect at high altitude.

For variable speed drives the effects of high altitude are particularly significant. At 4,700 masl, low and medium voltage drives have a power reduction factor of about 50 percent due to reduced cooling efficiency; correct dimensioning is, therefore, crucial. In addition, large medium voltage drives have heat losses of up to 145 kW and require more cooling air at this altitude. To counter this effect, ABB has equipped the medium voltage drives E-house with an innovative external ventilation module, which blows air into the E-house at the optimal temperature and with minimal energy consumption.

Fault current limitation and arc fault protection for the entire power distribution system is provided by a uniquely fast and effective ABB limiting and switching device, the Is Limiter. It is the only device capable of detecting and limiting a short circuit current at the first rise in less than 1 ms. Its role is to protect the air insulated switchgear from short circuit currents in the event of a power failure.

ABB was also responsible for the design, engineering and commissioning of the electrical system. The design was coordinated with ABB specialists in gearless mill drives and harmonic filter/power correction to ensure a secure supply network for the GMDs. Contact with Jacobs engineers was on a close and daily basis to ensure efficiency and speedy progress in engineering.

Integrated process control

The third major contract that Chinalco and Jacobs Engineering awarded to ABB was for the mine's process automation system.

The ABB solution is based on two flagship ABB products for the mining industry: Extended Automation System 800xA, which is ABB's market-leading automation platform for the process industries; and System 800xA Minerals Library, ABB's dedicated application software for the cement, minerals and mining industries.

The benefits of the System 800xA solution are many. It has a unique capability to seamlessly integrate all plant automation and enterprise information systems onto the same 800xA extended automation platform – from electrical integration and communications to safety, asset management and enterprise resource planning – and in an operations environment that is designed to maximize collaboration, operator efficiency and productivity.

At Toromocho, the System 800xA solution controls the entire processing area – the concentrator, molybdenum plant, main conveyors, pumping stations and utilities. The process is controlled from four control rooms – for the concentrator, primary crusher, molybdenum plant, and filter plant. The main control room is at the concentrator; the other three control only their respective processes. There are around 10,000 I/O points at the site.

The solution integrates all the power distribution equipment and all third-party equipment and automation systems onto the mine's System 800xA control system. Its parameterized object-oriented software modules help reduce engineering complexity, minimize downtime and simplify faultfinding. The ability of System 800xA and Minerals Library to reduce operating costs and increase productivity over the life cycle of the production facility is widely proven.

ABB Peru provided the automation solution, drawing on its extensive resources and expertise to design, engineer, test and commission the solution.

Integrated solutions

The advantages of using a single technology partner and supplier for the electrical, process control and gearless mill drives extend across the entire project – from start to finish. It minimizes the number of interfaces, reduces customer risk and saves a great deal of time - in engineering, testing and commissioning. Jacobs Engineering and Chinalco expressed these benefits as follows:

“The experience of doing business with ABB was really satisfactory,” said Gabriel Rojas Ochoa, electrical lead engineer for the Toromocho project for Jacobs Engineering. “We were able to build a really good working team which was focused only on one goal – the project's success. ABB gave us support along the project development, using their professionalism, commitment, high-level engineering support and flexibility to get the most suitable solutions for the project.”

Cyril Huber, electrical technical consultant for Chinalco, said: “After more than 50 years in the mining business, I am happy to work with ABB because although they have very standard solutions, they are flexible to adapt them to customer specific needs and are open for improvement.”

Production at Toromocho is scheduled to begin in November this year.