

Complete Trolley Assist Solution

Karl van Rensburg, Siemens South Africa Rail Electrification

Open cast mining has always been an opportunity for operation of diesel-electric driven haul trucks, which are powered by a diesel-electric drive system consisting in principle of two electric drive motors, integrated through gears into the rear wheels of the trucks, an electric generator/alternator and a powerful diesel engine.

Trucks with electric drive systems can be fitted with a Trolley Assist System, while mechanical trucks cannot be operated on a Trolley system. The Siemens (referred to as the company) truck Trolley Assist system involves the substitution of the diesel fuel by cheaper more ecological electric energy.

Instead of generating electricity from the diesel engine and generator on the truck, the electric energy is supplied from a dedicated substation (E-House) and fed to the electric drive and motors of the truck via overhead feeder lines.

The overhead feeder wires (catenary) are fed from a transportable rectifier substation called an E-House while the transformers are installed on a base/skid. The modular design allows for ease of relocating the system as mine activities progresses over time.

The E-House and equipment are robust and designed to cope with rough environmental and operational conditions, which include the continuous varying load conditions of between zero and 150%, depending on the duty cycle of the trucks.

The company provides the complete Trolley Assist solution, from the design stage, static calculations, supply and delivery of material to installation and commissioning of the entire system. The Trolley system can be used for mine operations, which has high demands for mechanical stability, operating reliability, low maintenance cost and a high availability.

Trolley Assist has been utilised at mining sites around the world since the early 1980s.

South Africa is regarded as a world-leader in installed capacity of this technology – having recently celebrated the launch of the 4th generation Trolley Assist substation technology.

The 11 MW substation boasts an output of 1,8 kV of dc voltage and up to 10 000 A to ensure the running of haul trucks with a nominal gross vehicle weight of 550 000 kg and a payload of approximately 325 000 kg.

The substation can accommodate a duty cycle of running two fully loaded trucks continuously, and under overload conditions allows for three trucks for ten minutes or four trucks for one minute along the overhead feeder lines of approximately 850 m sections.

The substation is housed in a 6 m x 3,3 m x 3 m E-house that weighs approximately 8 500 kg, and includes the 1,8 kV dc switchgear, rectifiers, 33 kV ring main unit, cooling equipment, battery charger,

control panel and the Siprotec ac - Sitras Pro dc feeder protection devices.

The control and protection of the entire substation is automated with a PLC and distributed Input/Output units interfaced via an industry standard Profinet fieldbus which significantly reduces the number of interface cables between equipment and allowing for the effective control and monitoring of the substation and equipment via a touch panel or from a remote location.

Cooling of the E-House is provided by two inverter air conditioners, keeping the inside temperatures between 18°C to 22°C under all operating conditions.

Another breakthrough is that 90% of components in the E-House are entirely manufactured by this company, compared to past E-Houses that contained approximately 30% the company's components. Sourcing nearly all of the components from the company's portfolio, guarantees compliance with International standards, greater quality control and improved functionality.

A further major benefit when compared with the previous generation of E-Houses is the improved safety features, as a result of the modular design of the ac/dc switchgear and rectifier modules that prevent direct access to live high voltage components.

Correct switching sequences and dc feeder line test procedures can now be implemented with failsafe software procedures, doing away with mechanical interlock keys.

From humble beginnings

In its early days, Trolley Assist involved two single copper contact bars, one for each of the positive and negative supply feeds, and heavy duty current collecting poles. Electric power was provided to the overhead lines via a roadside rectifier substation rated at a maximum power output of 3 MW.

In these first generation traction substations for Trolley Assist, the traction substations were fed from the public network, (typically 3 phase 11 kV to 36 kVac) and converted to the 1 200 Vdc voltage required by the trucks, which were equipped with dc motors.

These substations were generally constructed in two parts (a transformer skid and E-House) for portability, making it easy to relocate them as mining operations developed. The equipment for the



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South Africa is a world leader in installed capacity of Trolley Assist technology.

substations was largely pre-installed when delivered to the mine. This results in a shorter installation and commissioning period.

In the second-generation Trolley Assist system, the substation power increased to 5 MW, supplied from a medium voltage transformer (11 kV or 33 kVac).

It also consisted of ac switchgear, rectifier, dc switchgear, parallel feeder contact lines for the positive and negative poles, and a pantograph with sensor system to guide the truck driver along the haul road. With a Trolley dc voltage range between 1 200 – 1 600 Vdc, it was possible to power dump trucks with a payload of around 170 000 kg.

The third-generation substation technology gave rise to the demand for bigger trucks and the introduction of ac wheel motors. Output power increased to 10 MW with a nominal feeder voltage of 2 600 Vdc. The change from dc wheel motors to ac wheel motors and the associated drive technology significantly reduces costs and increased availability due to less scheduled maintenance. The higher torque produced by the ac motors and drive system means that the trucks can accelerate faster and reach higher speeds when carrying heavier loads. Faster and more sophisticated dc feeder protection relays were introduced to protect feeder lines against thermal overload and short circuit faults.

Logic control systems were introduced to allow the substations to be fully automated, with auto reclose dc feeder breakers which further reduced down time in the event of an external fault on the feeder lines.

Advantages of trolley assist

Normally the speed of a truck on a gradient is limited by diesel engine power. If the same truck could get more power by connecting to an overhead electric feeder line while travelling on an uphill gradient, it could sustain a higher speed. The diesel engine would be idling, and fuel consumption would be reduced by 95%, greatly reducing noise and emissions to the environment.

Billions of litres of diesel are consumed annually by the global mining industry, which is under severe pressure from weak commodity prices. Loaded haul trucks on uphill gradients typically accounts for 70 – 80% of a truck's total fuel consumption.

A Trolley Assist solution is installed on any uphill stretch between the loading area (pit) and offloading points (dump or process plant).

With the inclusion of the electric drives, the electric power supplied to the wheel motors of the haulage trucks enables the vehicles to move faster uphill, which results in quicker turnaround times and higher productivity for the mining operation.

For example, if the duty cycle time is reduced by 20% as a result of the increase in speed on the uphill gradient, a fleet of 32 trucks on trolley can produce the same results as 40 trucks operating on diesel. This results in reduced capital costs if the study is done at the feasibility stage. Engine operating and maintenance costs are directly linked to hours of operation of the haul trucks and using Trolley Assist on gradients reduces the cycle time of the haulage trucks, thus increasing the intervals between maintenance schedules.

The technology has been supplied to open cast mines in South Africa, Namibia, the DRC, Zambia and as far afield as North America. New business interest has come from mining companies in Botswana, DRC and Sweden.

The goal of mining corporations is always to reduce the cost per ton of the commodity produced over the life cycle of the assets, and the trend is clearly toward larger trucks, shorter cycle times with a leaner fleet and overall lower cost of ownership, all of which can be achieved by the benefits of a Trolley Assist solution.

Conclusion

This E-House concept is being promoted to the rail customers. Recently, a 5 MW, 3 kV dc containerised substation was commissioned in the Northern Cape. This E-House solution was designed to comply with the specifications of the rail customer.

The recent developments in the 11 MW dc E-House solution and the 5 MW, 3 kV dc solutions make it exportable to international markets.

Karl van Rensburg works in rail electrification at Siemens South Africa. Enquiries: Jennifer Naidoo. Email Jennifer.naidoo@siemens.com