

## The Good, the Very Good and the Hyper-SER®

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### Background

The Kansanshi copper-gold mine is located in the North Western Province of Zambia and in 2001, First Quantum Minerals Ltd acquired an 80% interest in the mine. In 2002, it was proposed that Kansanshi be developed in two phases, with the first and second phases of 16 and 14 years respectively, supported by a total mine life of approximately 30 years.

Mining is carried out using conventional open pit methods and ore treatment is flexible to allow for variation in ore type. Sulphide ore, for example, is treated via crushing, milling and flotation to produce copper in concentrate whilst the oxide ore is treated via crushing, milling, solvent extraction and electrowinning (SX/EW) to produce cathode copper.

In 2003, following a competitive tender, Outotec was awarded the contract to supply Kansanshi with a low aspect SAG mill. Not only did variations in ore type and throughput need to be considered in the mill design, but the design also needed to be robust and flexible enough for future expansions at the site. The resulting mill design was 6.1m dia x 9.05 EGL SAG Mill with a 5.2MW Wound Rotor Induction Motor (WRIM). This mill was delivered and installed by Outotec just 52 weeks after the order was received.

### Design – with foresight

Due to the SAG mill's performance and also an increase in throughput at Kansanshi, First Quantum subsequently ordered a Ball Mill for site in late 2004, with this design to have as many common components as possible with the existing SAG mill. Despite the Ball Mill's higher charge level and an increased installed power of 5.8MW, the conservative initial SAG mill design resulted in a Ball Mill with an identical structure, trunnion bearings, girth gear, pinion and pinion bearings. The Ball Mill required a larger gearbox, but both the WRIM and inching drive were dimensionally interchangeable with the existing SAG mill components.



*Final commissioning of Kansanshi's 12MW SAG and 5.8MW Ball mills*

The commonality of parts facilitated numerous benefits. Operations and maintenance crew, for example, were already trained and familiar with the mill components – so this ensured greater operator familiarity, ease-of-use and also interchangeability of spare parts between the two mills. The value of such operator familiarity and part flexibility cannot be overestimated in challenging remote locations – particularly with the mill, often regarded as the ‘heart’ of a mine’s operation. This Ball Mill was installed at Kansanshi late 2005.

## Repeat business

This foresight was to also prove invaluable for subsequent orders by First Quantum. In 2005 the company proceeded with the development of the Frontier Project in the Democratic Republic of the Congo. Again, First Quantum and Outotec were planning not just for the present but also the future, and SAG and Ball Mills were ordered with the same conventional and flexible design philosophy as those at Kansanshi, ensuring a similar level of service and spare parts benefits at Frontier.

## Precious months saved

The Frontier Ball Mill was designed to be identical to the one at Kansanshi, with interchangeable girth gear, pinion, gearbox and motor. The timing was such that as the Kansanshi Ball Mill was being manufactured when the Frontier order was received, many valuable months were saved as the moldings and processes could simply be repeated for the identical mill at Frontier.



*Frontier’s SAG and Ball mills*

## Design goes Hyper-SER® !

The requirements at Frontier were for a grinding circuit design to comfortably handle the variations in ore and throughput (the Frontier orebody was harder than that at Kansanshi) and also the challenges of operating in a remote site. So the Ball Mill at Frontier was yet again designed with robustness and performance in mind, but the trunnion-supported, high aspect 9.75m (32’) diameter SAG mill was the real technical tour de force. The supply of this dual-pinion driven mill with 12MW of installed power included a Hypersynchronous Slip Energy Recovery Drive (Hyper-SER®). This innovative engineering ensured extremely high efficiency of the mill’s

operation, allowing easy management of variable feed rate and feed competency. The design also facilitated optimised handling of any variations in ore, on both a daily basis and throughout the mine life of the orebody. The variable speed drive ensures optimised trajectory for the charge during mill operation, maximising energy efficiency and minimising unnecessary wear of the mill lining.

## **Ultimate performance, optimised saving**

Conventional sub-synchronous SER drives utilise a special transformer circuit to recover the slip energy that is normally wasted during variable speed operation of a WRIM. The Hyper-SER® drive is configured to allow extra energy to be added to the rotor circuit via the recovery transformer and operate the motor at above synchronous speed. The variable speed operation required for the Frontier SAG Mill could have been achieved by using a large dual variable speed Liquid Resistance Starter (LRS), however this technology would not allow commonality of drive train spares and is far less efficient, as the slip energy is wasted instead of recovered. For example, a 12MW variable speed LRS drive operating at full load and 15% turn-down continuously wastes 1.8MW of power. This wasted energy must be dissipated using a heat exchanger in the LRS and a water cooling circuit. The Hyper-SER®, on the other hand, allows a greater range of mill speed variation and a drive efficiency greater than 99% over the entire speed range. In addition, using the Hyper-SER® drive (as opposed to a conventional sub-synchronous SER drive) allowed the entire drive trains and WRIMs to be designed identical and interchangeable to the Frontier Ball mill and the Kansanshi Ball Mill.

## **Remote location, reliable performance**

This customised grinding system at Frontier was designed for optimal operation, which is critical especially at remote sites which can be prey to challenging situations such as power supply voltage and frequency variations and thus unavoidable downtime. The Hyper-SER Drive® supplied to Frontier is capable of withstanding these variations. The Hyper SER Drive® can transfer to fixed speed mode during under-voltages, then transfer back to variable speed when the supply voltage stabilises, ensuring no costly mill stops occur. Also, if the Hyper SER-Drive® is being serviced, the mill can be operated in fixed speed mode while repairs are made. The simple, modular design of the Frontier Hyper SER-Drive® also allows fast change-out of most components by HV technicians.

## **Further Kansanshi Expansion**

In 2008, Outotec subsequently supplied and installed an additional 9.75m (32') diameter, 12MW SAG mill with Hyper-SER Drive® and 5.8MW Ball Mill at the Kansanshi site, again with common, interchangeable drive train components. The original 5.2MW low aspect SAG Mill will also be converted for operating as a Ball Mill. This expansion is currently in the final stages of commissioning, which will take the total installed power of Outotec grinding mills at First Quantum's sites to almost 47MW.

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Bjorn Nielsen is currently Proposals Engineer - Grinding for Outotec Pty Ltd. He has a double bachelors degree in Mechanical Engineering and Materials Chemistry from UWA. Bjorn specialises in grinding mill technologies for Outotec and he has over 5 years experience in the sales, selection, design, manufacture, installation, maintenance and failure analysis of heavy rotating equipment in minerals processing and other industries in Australia and around the world.

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