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MEASUREMENTS AT A STATE OF THE ART 2 X 5 MW DUAL PINION MILL DRIVE

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ABSTRACT

Until not so long ago most ring geared mills were operated with fix speed motors only. By using the latest generation of medium voltage frequency converters, new possibilities have arisen to improve the grinding process. Beside all the direct and indirect advantages, several dedicated functions have now been implemented for ring geared grinding mills in the minerals industry. The sophisticated operational functions ensure a smooth, safe and reliable operation with minimum stress for the mechanical equipment and therefore utmost availability of the mill. Several papers have already been presented concerning the benefits of using this state of the art technology for mill drives. Now this paper is focusing on the experiences gained with this kind of sophisticated ring geared mill drive system rather than only show and explains the operational benefit of the different functions. Several measurements of different operating conditions, starting, frozen charge remover, controlled roll back, backlash, etc., made on an installed and commissioned 2 x 5 MW dual pinion ring geared mill drive system will be shown and discussed. The accuracy of the load sharing between the two 5 MW motors during starting, normal operation and stopping will be demonstrated using real measurements from an operating system. Finally the inherent features of these drive systems are briefly discussed.

INTRODUCTION

Looking at the demands of grinding mills, we can split them into operational, maintenance and protective demands. For smooth and safe operation, it is important that critical situations are avoided as much as possible. Maintenance functionality must be quick and easy to execute, while protection of the system is important during all operating conditions. ABB has considered all these demands during development of their dedicated mill functions. By adding an additional controller (mill controller), not only a lot of application related functionality and protection is included, but also the interface between the mill drive system and the customer's distributed control system (DCS) is simplified.

When talking about ring geared mill drives (RMD's) and especially dual pinion systems (see figure 1), the possibility to add mechanical stress by the motors can be significant. Therefore the control concept between the two motors must be fast and accurate to avoid any additional stress to the pinions and the ring gear.
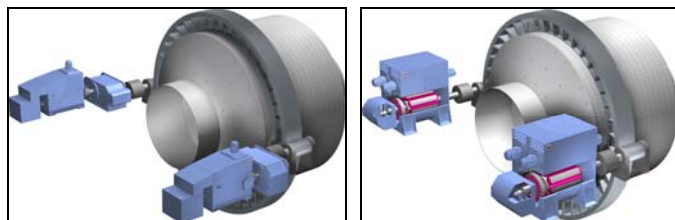

Figure 1. Dual pinion high-speed mill drive (with gearbox) and dual-pinion low-speed mill drive (without gearbox).

By using the latest generation medium voltage frequency converter drives of ABB as shown in figure 2, with exclusive DTC (direct torque control) technology, these demands can not only be reached, but even exceeded. DTC is the most advanced control method for AC drives, where the motor variables, torque and flux, are directly controlled by inverter switching. Operational and maintenance related functionality can be only added by using variable speed drives and by use of its control accuracy. In addition, all inherent features from a frequency converter drive have a positive influence on the system and give much more flexibility in the control of the complete grinding process. Very accurate current and torque measurements, power drop ride through, earth fault and short circuit protection are only some of these benefits.
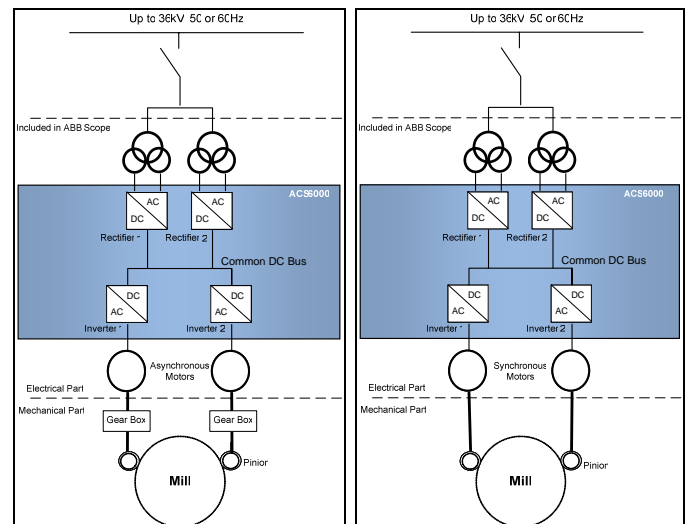

Figure 2. Simplified overview of dual pinion high-speed mill drive (with gearbox) and dual-pinion low-speed mill drive (without gearbox).

On the larger ring geared mills, where the length of the pinion and ring-gear teeth is increasing, perfect alignment of pinion and ring gear (and gearbox in some cases) is pivotal. On the other hand experience has shown that it can be difficult to achieve and maintain perfect alignment. Thus especially for the larger mills, it is essential to avoid rough starts, torque spikes, etc. A mechanical friendly system is required during all operation conditions (starting, normal grinding operation, stopping).

This paper is showing and explaining the drive system performance and improved mill operation using the example of a dual pinion ring geared pebble mill with a total power of 10MW (2x5MW). The electrical drive system configuration consists of a three winding, a converter transformer, an ACS 6000 multidrive medium voltage frequency converter and two AMI630 four pole squirrel cage asynchronous motors. Dedicated mill functions will be explained in theory and their performance is proven by real field measurements to emphasize how important these functions are in the daily operation of the mills.

MILL STARTING AND STOPPING PROCEDURE

Let's start with a complete start/stop sequence of this mill drive system.

The start sequence is completely controlled by the drive system. The customer's DCS can send a simple start command and the desired operation speed reference. The drive system will perform a smooth and safe start: First ramping up to a predefined starting speed, typically about 10% of nominal speed. While maintaining this speed, both the torque and the mill angle are monitored.

Only if the mill controller measures cascading of the material, by a decreasing torque, before the critical angle is reached, does it release the drive to follow customers DCS speed reference. From then on, the drive is in the customer's hands, which means it will follow accurately any speed change requested by the DCS.

When a stop command is received, the mill controller will again take over full control of the stop sequence. To avoid unnecessary long rocking back and forth of the mill, ABB has implemented a function called "controlled rollback" to bring the mill to a balanced rest position in a controlled way. Speed is first ramped down to zero, but transfers almost immediately into a negative speed to roll back the mill. Only if no torque is remaining in the system, will the drive switch off. With this procedure, the time to stop the mill can be reduced comparing to a coast stop, which leaves the mill rocking.
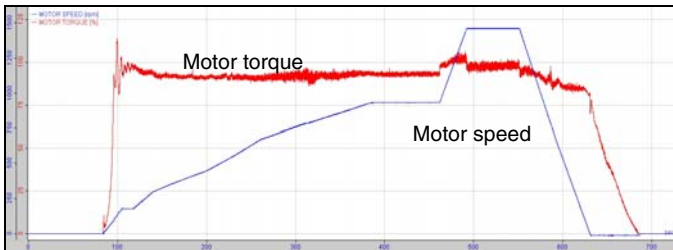

Figure 3. Complete start/stop sequence.

In figure 3 we can see that the speed is slowly ramped up while the torque is increasing. Only after detected cascading of the ore, the mill controller releases the drive to increase to customer's speed reference.

When initiating a stop, speed is reduced to zero and then the mill is rolled back in a controlled manner with slight negative speed until no torque is remaining in the system.

Start Sequence
During start up of a mill, there is a potential risk of a dropping frozen charge which can seriously damage the mill shell, mill bearings and/or other equipment. There are many examples of dropping charges in the grinding industry, especially with ball mills. ABB's mill controller takes care of the starting sequence in such a way that the risk of a dropping frozen charge is eliminated. Therefore no further actions like creeping are required before giving a start command, even after a longer downtime of the mill. If there is really a frozen charge in the mill, the drive will trip and perform a coast stop before the critical angle is reached.

The start is typically initiated from DCS, but it is also possible from a local control panel close to the mill. First the operator has to pre-select normal mode, direction of rotation and the desired operation speed reference, followed by giving the start command.

Figure 4 shows a close view of the starting area of the start/stop sequence of figure 3. The first small torque peak in the beginning is the break away torque. After that, the speed is ramped up slowly while the torque is increasing with the rotating angle of the mill. At an angle of approximately 30°, the material starts to cascade (first main torque peak is approx. 94% of rated torque, second and maximum torque peak is approximately 113% of rated torque). After this detection of cascading charge, the mill is released to continue running at low speed, until continuous cascade is reached.

This is seen through the constant torque measured at the motor. At an angle of approximately 200° the system runs stable and the mill controller releases the drive to follow DCS speed reference and therefore the drive starts to ramp up. It has also to be noted that the

starting is extremely smooth for the mechanical components such as gearbox, pinion and ring gear, as no huge torque spikes occur. The motor torque is smoothly ramped up and the mill is gently brought up to speed. The maximum possible motor torque can be limited in the drive with separate levels for starting (higher torque limitation, e.g. 130% of rated torque) and for normal operation after starting (lower torque limitation, e.g. 110% of rated torque).
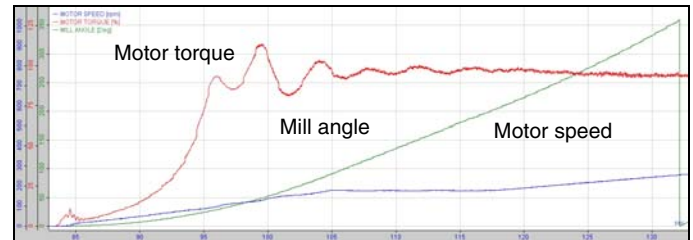

Figure 4. Start sequence with frozen charge protection.

The starting is not only very mechanical friendly, but is also very smooth towards the electrical supply network. Because the motor is decoupled from the network via the ACS6000 converter, there are no high starting currents, as typically occur with direct-on-line motors. In this case the current draw from the network during starting is, at the maximum peak of 113% rated torque, only about 12% of the rated current. This 12% is the current on the network side; obviously the motor current itself is higher.

Figure 5 shows the calculated network current which is seen by the supplying network on primary side of the converter transformer. Even if the torque on motor side is very high during startup, due to low speed the consumed system power is low and therefore also the current on network side is low. Therefore the startup sequence with an ABB mill drive is very network friendly.
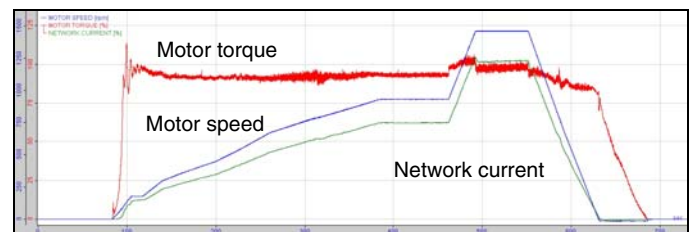

Figure 5. Calculated network current during start/stop sequence.

Operation Area
As soon as the cascading of load has been detected and the mill runs stable, the mill controller releases the drive to ramp up to the customer speed reference received from DCS. Now the speed can be adapted by the operator according to process requirements. The electrical drive system can deliver constant torque over the whole speed range between starting speed and nominal speed. It is also possible to run above nominal speed, but with reduced torque (constant power operation area).

In figure 6, the operator ramps up the speed reference slowly. In this specific case after remaining for more than a minute at 2/3 of nominal speed, the mill is ramped up to full speed of almost 1500rpm (motor rated speed). On this measurement, it can be observed that the torque is pretty constant over the whole speed range. During the final ramp up to nominal speed, it can be seen that the acceleration torque is about 7% of nominal torque.

After the mill controller receives the stop command from the DCS, it starts to ramp down the speed. When reaching zero speed, the drive system slowly starts in the reverse direction to roll back the mill until no torque is remaining in the system. During this time, the motor is acting as a generator, taking back the potential energy which exists in the system due to the material which is still lying in the mill with a certain angle. In this type of drive system, which has a diode bridge rectifier and therefore no possibility to feed back energy to the network, the negative speed to roll back the mill is relative low. This is because of the generative power is limited by the losses of the drive system (motor

and inverter/dc link of the frequency converter). ABB offers also as an option a truly 4-quadrant drive system with an active rectifier unit giving the possibility to feedback braking energy to the network; then the time required to roll back the mill can be significantly reduced.
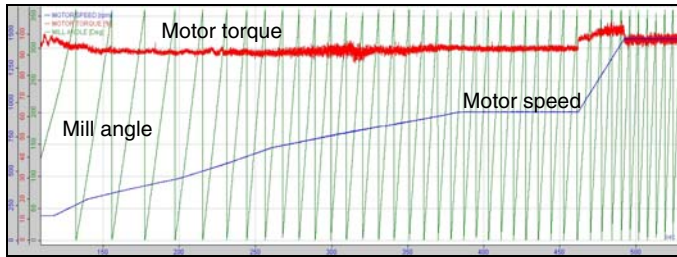

Figure 6. Normal operation.

Stop Sequence with Controlled Rollback

Figure 7 shows the stop procedure of the start/stop sequence of figure 3. Figure 8 shows a close up of the controlled rollback area.
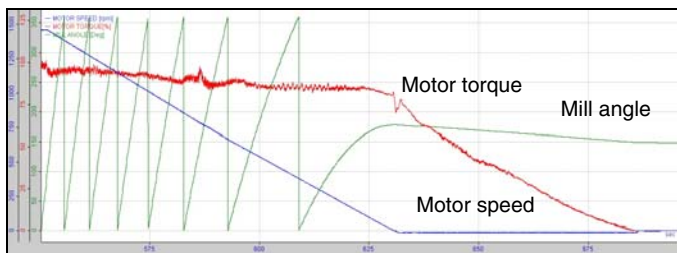

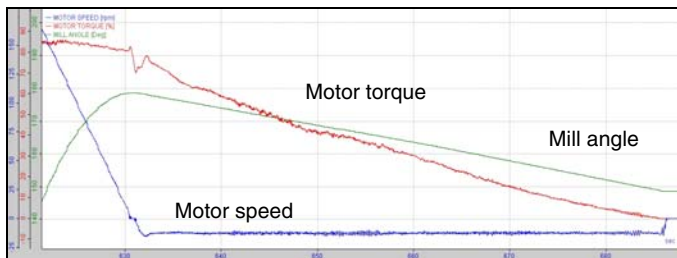**Figure 7.** Complete stop sequence.

Figure 8. Close up view of controlled rollback.

Figure 8 shows, that when the mill speed has been ramped down and the mill is in unbalanced position, the motor first creates a positive torque to just hold the mill with the charge unbalanced. Then by slightly reducing the torque the direction of rotation is changed and the mill is gently rolling back until the mill charge is in balance. The measurement in figure 8 clearly shows that the torque is always positive during the complete procedure. Because the torque is always positive, even during the time that the mill changes direction of rotation, no backlash phenomenon occurs between the pinion and ring gear. If backlash would happen, it would be seen by a drop in torque to zero or even negative values. Therefore, since there is always a positive torque applied to the pinion teeth, the contact between pinion and ring-gear is always maintained. Backlash can therefore not occur.

In this particular case, the speed during controlled rollback is only 12.8 rpm (at the motor), which is about 0.85% of nominal speed! In other words, the mill itself is smoothly rolled back in a controlled manner with about 0.1 rpm. Due to the ABB's advanced DTC technology, the system is still running stable at this very low speed. The time between reaching zero speed (after ramping down from operational speed) and reaching zero torque (mill stopped, no overshooting), takes about 55 seconds in this configuration. This is significantly faster than a coast stop with rocking of the mill, but could even be much faster by using a converter setup with four quadrant capabilities.

By looking at the angle curve, it can be observed that the mill was rolled back by 30°. This matches perfectly with the measured cascading angle during the startup in figure 4.

Coast Stop (Rocking Mill)

To make a direct comparison with a drive system without the possibility for variable speed operation and therefore no controlled rollback, a coast stop from nominal speed was tested on the same mill. Please refer to figure 9 for the corresponding measurements.

Total time between receiving the coast stop command and stand still of the mill is about 180 s. During this time, the mill is rocking back and forward for more than 15 times. The amplitude of the mill angle is about 20° in the beginning.

By having a closer look at the motor speed signal (measured by tachometer on the motor) as shown in figure 10, it can be observed that there is some backlash between the teeth of the pinion and the ring-gear, because the ring-gear is driving the motor which has to be accelerated and decelerated due to its inertia. Especially when changing from acceleration to deceleration the tooth of the ring gear hits the tooth of the pinion several times to break the motor speed. This backlash can, of course, not occur when stopping the mill with the controlled roll back function. Therefore a coast stop is adding more stress to the teeth of the gears than a controlled rollback.
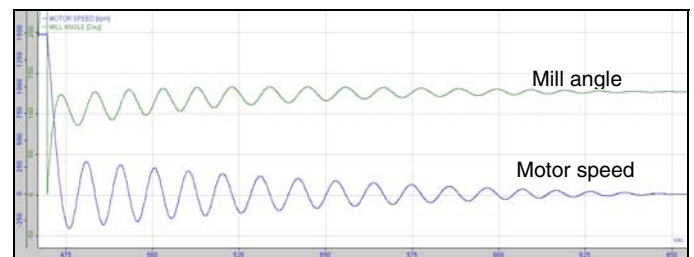

Figure 9. Coast stop (rocking mill).

Figure 10. Backlash during coast stop.

MAINTENANCE FUNCTIONS

For fast, easy and safe maintenance of the mill, ABB has implemented dedicated maintenance functions in the mill controller. Most of these maintenance functions have already been discussed in other papers (Ravani von Ow and Bomvisinho, 2010; Ravani von Ow and Gerhard, 2010).

Creeping

Creeping is a common maintenance function for mills. It is nothing more than turning the mill at very low speed for maintenance purposes – like visual inspection of bearings or manual positioning for liner change. Mills using fixed speed motors for the main drive system need an auxiliary motor with a reduction gearbox to perform creeping. ABB's mill drive systems, with frequency converter, can provide high torque at low speed, and therefore creeping is possible with the main drive.

The creeping command is preferably initiated from a local control panel close to the mill, but it is also possible to be activated remotely from the DCS. To start creeping, the operator can pre-select the creeping mode and direction of rotation (if possible/allowed by the mill type), followed by a start command. A speed reference is not required, because the mill controller will start up to the creeping speed, which is typically 5% of nominal speed. The start procedure is, again, completely controlled by the mill controller, similar to the normal start. This means that also frozen charge protection is activated when creeping mode is selected. After a successful start, (cascading is detected), it is also possible to adjust the creeping speed within the range of 1-10% of nominal speed. Lower speeds are used, for

example, for visual inspection of the mechanical equipment and after any mechanical problems that may have occurred. On the other hand, faster speed is helpful when manual positioning of the mill is required. A new position is reached as fast as possible.
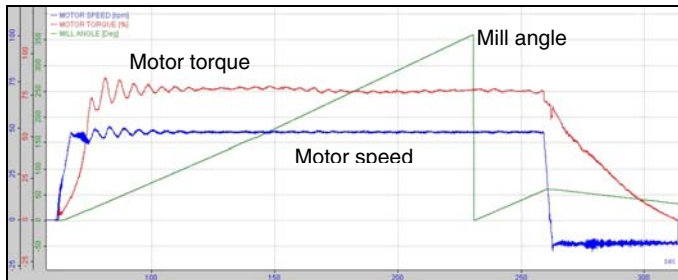

Figure 11. Creeping routine.

In figure 11 the measurement of the complete creeping sequence is shown. After ramping up to creeping speed (48 rpm or 3.2% of nominal speed) the drive monitors the torque and angle and detects cascading at 23.5° mill angle at a torque of 73% of nominal torque. The operator keeps the mill running at this speed for 420°, then initiates a stop command. The mill controller ramps down speed and performs a controlled rollback until no torque is remaining in the system, and then stops the drive.

Automatic Positioning Sequence

The automatic positioning function allows the operators to turn the mill by any desired angle or number of liner rows. It is a very helpful function during liner replacement. Ideally, this command is initiated by a local control panel, located close to the mill. Alternatively, it can also be done from the DCS. The operator can pre-select positioning mode, preferred direction of rotation and set the desired angle, or number of liners. After that, only the start command is required. The rest will be arranged by the mill controller. Due to the controlled rollback function, the mill ends up in the desired position without any torque remaining in the system. The sequence stops automatically and switches off the drive after the position is reached. Of course, a forced stop command can be given at any time also during the positioning routine is still running.

After the drive has received the mill angle reference and the start command from the local control panel or the DCS, it starts to slowly ramp up to speed. Typical speed for the positioning routine is about 10% of nominal speed. The function is implemented in such a way, that the cascading angle of the material is considered. Together with the controlled rollback, a torque free position can be reached very accurately.

Figure 12. Automatic positioning routine with 180° angle reference.

Figure 12 shows measurements with the automatic positioning function, where a 180° turn was requested. It can be seen, that the material cascades at 27°. The drive keeps running on a constant low speed for a certain time and then starts to ramp down. By reaching zero speed, the mill has already turned 209°. At this point of time, the torque value is at 94% of nominal torque, which means the mill is fully loaded. Now the drive starts to run in reverse, reducing the torque slowly. Only when zero torque is reached, the drive will stop. The mill has finally turned 179.2°, which is an inaccuracy of only 0.5% and the total time for the complete sequence is only 101.6 seconds! Therefore it can be clearly said, that the automatic positioning function is faster and much more accurate than manual positioning, using the creeping

function; consequently the downtime for liner change can be reduced and higher mill availability is achieved. ABB's commissioning engineers are tuning this function until an optimum between speed and accuracy is reached. In this case, the positioning speed was finally selected to be 158 rpm which corresponds to 10.5% of nominal speed. At this speed, the angle inaccuracy was below 1% during all tests!

Deformation Protection

Deformation protection, historically coming from the kiln drives in the cement industry, is just an automatic positioning sequence with a fixed angle reference of 180°. Even if deformation is not a real problem for grinding mills in the minerals industry, the function can still be used during longer stops of the mill, for example, due to maintenance works on other equipment to avoid a frozen charge occurring. This function can also be initiated either from a local control panel or from the DCS. Operators can pre-select deformation protection mode and the preferred direction of rotation. After that, only the start command is required and the mill controller will take care of a 180° turn, exactly as shown in the measurement in figure 12 above.

Frozen Charge Remover

As mentioned earlier, there are several examples in the industry where a frozen charge has occurred; typically they occur on ball mills, not on SAG mills. ABB's dedicated mill functionality not only protects the mill from a dropping frozen charge, it also offers a patented function called frozen charge remover. Usually the first task for an operator after a frozen charge has been detected is to get the frozen material removed. In the case of ABB Mill drives, a function to assist the operator is available in the controller. The function can only be initiated manually by the operator from a local control panel or from DCS. Direction of rotation can be selected before starting the sequence. Without the frozen charge remover function, the frozen charge needs to be manually removed, in some cases, with a jack-hammer, a bobcat or similar. It is obvious that this would automatically lead to significant down time of the mill.

The frozen charge remover function tries to loosen the material by applying torque steps to the system. The optimal amplitude and the duration of the steps are found and set during the commissioning by ABB engineers. The amplitude of the torque steps are defined in a way that they are adding a certain percentage of the actual torque to the system, while all the protection functions like torque and current limits are still active and working on the same levels as during normal operation. Therefore, the stress for the mechanical equipment never exceeds values that can occur during normal operation. After the frozen charge remover has stopped, a normal start can be tried. If again frozen charge is detected by the mill controller, the frozen charge remover can be applied in the other direction.

Figure 13 shows a frozen charge remover sequence in positive direction including controlled rollback. Soon after break away of the mill, torque steps are applied to the system. This is also reflected by speed changes. This is implemented by a sequence of accelerating and decelerating phases, which are used to try to loosen the frozen charge.
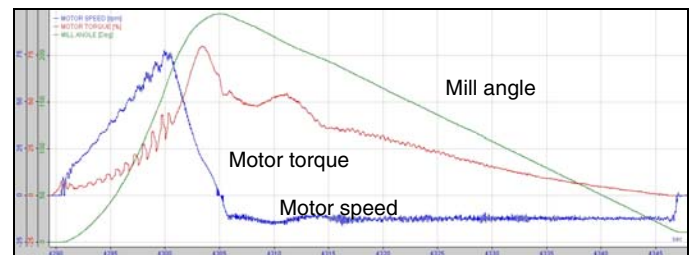

Figure 13. Frozen charge remover with controlled rollback.

Figure 14 shows a detailed measurement of the torque steps applied by the frozen charge remover function. It can be observed, that the amplitude of the steps is a fixed relative value of the actual torque which is added to the system. The maximum amplitude which was measured on the biggest torque step is 19.2% of nominal torque. The torque step amplitude can be adjusted during commissioning. It can

also be seen, that torque as well as speed are always positive and therefore no backlash phenomenon occurs between the pinions and ring gear. If backlash would happen, it would be seen by a drop in torque to zero or even negative values, but since torque and speed are always positive, operation is always in the same quadrant (first quadrant: positive speed, positive torque). Therefore since there is always a positive torque applied to the pinion teeth, the contact between pinion and ring-gear is always maintained. Backlash can therefore not occur.

Figure 14. Frozen charge remover torque steps.

DUAL PINION SYSTEM

In all above measurements, the speed and torque was shown only for one of the two motors (master drive) of the dual pinion system. The reason was to make the measurements more reader friendly.

In this chapter we will have a closer look at the master/follower application for dual pinion mills and the control accuracy of such a system, emphasized by measurements made on an installed and commissioned 2 x 5 MW dual pinion ring geared pebble mill (see figure 15).

Master/Follower Configuration

In some applications a system is driven by more than one motor, and the motors are mechanically coupled to each other. This coupling can be hard, soft or somewhere in between, but in any case load sharing between the motors is critical. With ABB's sophisticated DTC (Direct Torque Control) fast and accurate load sharing is ensured. There are different ways to achieve this load-sharing in ABB drives, and after thorough investigation, the most suitable algorithm for the application is applied. The link is established by a fast fiber optic connection between the main control boards of the drives.

Figure 15. 2 x 5 MW dual pinion ring geared pebble mill.

In the dual pinion mill application, where the two motor shafts are relatively hard coupled via the ring gear, it is essential to maintain equal load distribution in order to minimize mechanical stresses and backlash phenomena. Especially on the larger dual pinion ring geared mills, where the length of the pinions and ring-gear teeth is getting longer, perfect alignment of pinion and ring gear (and gearbox in some cases) is pivotal. However, experience has shown that it can be

difficult to achieve and maintain perfect alignment. Therefore especially for the larger mills, it is essential to avoid rough starts, torque spikes, load oscillations between the two motors, etc. During all operation conditions (starting, normal grinding operation, stopping) a mechanical friendly system with smooth, fast and accurate load sharing is required.

While one drive is called the Master, receiving the speed reference via the mill controller from the DCS, the other drive is called the Follower and is following the Master's speed and torque reference. The following measurement will show some details of the control accuracy of the Master/Follower configuration of this dual pinion system.

Start/Stop Sequence (Master/Follower)

The measurements shown in figure 16 are the same as shown in figure 3, but now displaying the individual speed and torque signals for both motors. As expected, on the first view there is no visible difference in the signals.
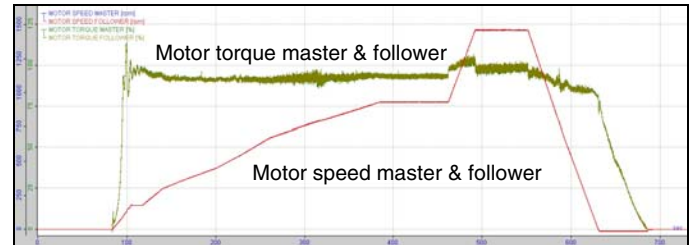

Figure 16. Complete start/stop sequence of master and follower drive.

Start Sequence (Master/Follower)

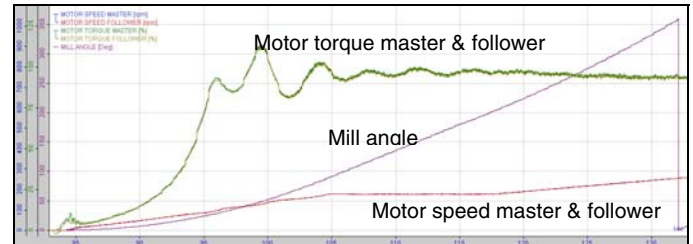Figure 17 shows a detailed view of the start sequence.

Figure 17. Start sequence (master/follower).

This is again the same measurement as in figure 4, but now showing the individual speed and torque signals for both motors during the start up sequence. Even in this detailed zoomed in graph, it is hardly possible to see any difference in torque between the two motors.

Stop sequence Master/Follower with Controlled Rollback

The same can be said about the stop procedure; also during controlled rollback, no significant torque difference between the two motors can be seen. Figures 18 and 19 show basically the same measurements as previously discussed in figures 7 and 8, but now for the two motors driving the dual pinion mill. After the mill is ramped down to stand still, both motors first create a positive torque to just hold the mill with the charge unbalanced, then by slightly reducing the torque the mill is gently rolled back until the mill charge is in balance. Figure 19 shows clearly that the torque values of both motors are always positive during the complete procedure. Because the torque is always positive, even during the time that the mill changes direction of rotation and during controlled roll back, no backlash phenomenon occurs between the two pinions and ring gear. If backlash would happen, it would be seen by a drop in torque to zero or even negative values. Therefore since there is always a positive torque applied to the teeth of both, the contact between pinions and ring-gear is always maintained. Backlash can therefore not occur.

Again, because this type of drive system with a diode bridge rectifier has no capability to feed back energy to the network, the negative speed to roll back the mill is relative low. This is because the generative power is limited by the losses of the drive system (motor

and inverter/dc link of the frequency converter). ABB offers also, as an option, a truly 4-quadrant drive system with an active rectifier unit giving the possibility to feedback braking energy to the network. The time required to roll back the mill can then be significantly reduced.
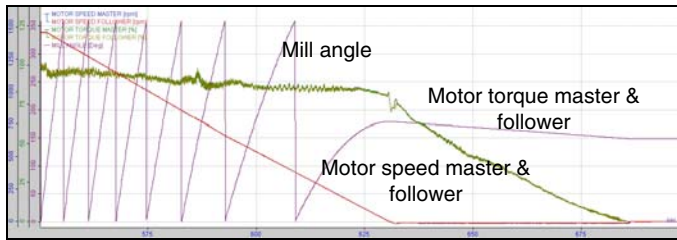

Figure 18. Complete stop sequence (master/follower).

Figure 19. Close up view of controlled rollback (master/follower).

Torque Difference during Operation between Master and Follower

In this measurement a synthetic signal was created, by subtracting the master motor torque from the follower motor torque. During the whole operation area, the torque difference between the two motors is below 1% of nominal torque. Only during brake away in the beginning and during break away into negative direction (when starting controlled rollback), the torque difference is slightly larger for a very short moment (less than one second), but still clearly below 3% of nominal torque. It has to be noted that the peaks shown in this figure 20 are not torque peaks as such, but show only the difference in the actual torque values of the two motors. Therefore it can be concluded that the load sharing between the two motors is functioning both very accurately and smoothly.
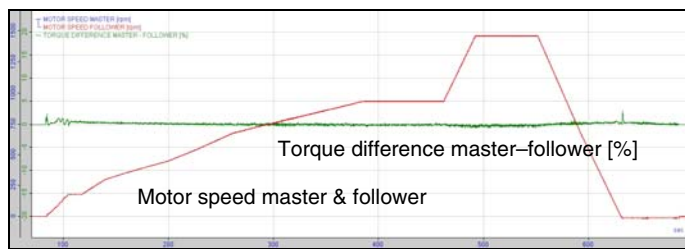

Figure 20. Torque difference between master and follower motors.

Speed Difference during Operation between Master and Follower

To complete the investigation on control accuracy between master and follower motor, a synthetic signal was created, by subtracting the master motor speed from the follower motor speed. Due to the relatively stiff coupling between the motors through the ring-gear, it is obvious that there are no big differences in speed possible. The measurement in figure 21 shows a maximum speed difference of 0.5% which occurs on startup, because the two motor do not start in the exactly same time. During normal operation, it is always below 0.3%.

Frozen Charge Remover (Master/Follower)

During frozen charge remover, the follower's torque is matching perfectly the master's torque and no signs of oscillations or backlash can be observed (see figure 22). If backlash would happen, it would be seen by a drop in torque to zero or even negative values, but since torque and speed are always positive, operation is always in the same quadrant (first quadrant: positive speed, positive torque). Therefore since there is always a positive torque applied to the teeth of both

pinions, the contact between the two pinions and ring-gear is always maintained. Backlash can therefore not occur.
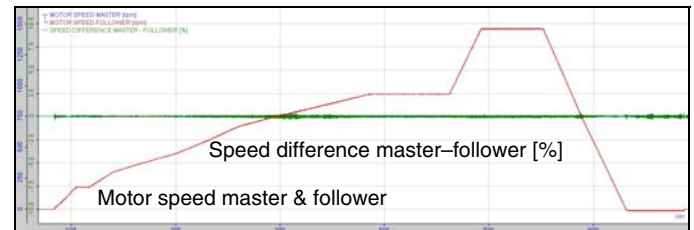

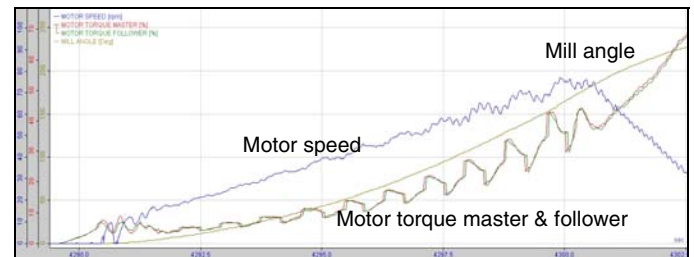**Figure 21.** Speed difference between master and follower motors.

Figure 22. Frozen charge remover (master/follower).

INHERENT FEATURES

The measurements discussed above show the clear direct advantages of the unique DTC technology, resulting in a flexible mill drive system with several unique operational features. As shown and discussed, this sophisticated technology is also mechanical and electrical friendly. In addition, by using this technology, the door for several inherent features has been opened. Besides the valuable frozen charge protection and frozen charge remover function and other features of this drive, the mill speed can be smoothly varied. Although basically all SAG mills world wide are equipped with variable speed mill drives, ball mills are nowadays sometimes still installed with fixed speed mill drives. It has to be mentioned that the speed of most large ball mills in Latin American concentrators can be varied and experience show that this is actually done in some cases. Basically all of these large variable speed ball mills in Latin America run most of the time continuously, due to several reasons (Ravani von Ow and Bomvisinho, 2010; Ravani von Ow and Gerhard, 2010), at a different speed than the original designed rated speed! This is only possible because the mill drive systems selected, offer indeed this flexibility. Several non standard operating conditions in the grinding process can occur, where variable speed on the ball mills would be very beneficial. In general, a variable speed on the ball mill increases the level of flexibility. Without flexibility, the operator can just either switch on or switch off the mills.

With higher flexibility levels in the grinding process, the more possibilities the operators have to try to reduce re-circulating loads, to increase the overall grinding efficiency and to increase the mill availability.

CONCLUSION

ABB's dedicated mill functions are adding significant value in regards to efficient operation and maintenance of grinding mills. The measurements presented in this paper make evident that these functions are not only nice in theory, but they work with amazing accuracy in the field.

With these measurements, it is proven that ABB's master/follower drive system concept for dual pinion mills works exceptionally smoothly, accurately and gently to all connected mechanical equipment. The benefits are: less maintenance, lower costs and a longer lifetime of the equipment. In addition, together with the inherent feature of being able to vary the mill speed, the complete grinding process is brought to a much higher level of flexibility, resulting into higher availability and higher overall grinding efficiency.

REFERENCES

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