Modern drive technology for belt conveyors

Smoother, faster and more efficient

Regulated drives can considerably improve the effectiveness of belt conveyor systems while lowering wear on mechanical components. Siemens has installed converters in the conveyor drive stations at Vattenfall Europe’s Reichwalde open-pit mine. New systems and procedures help optimize technological process chains.

Since the 1950s, belt conveyors have become established as an effective means to transport bulk material. The largest and most powerful belt conveyors are found in mining applications, which were the first to be equipped with converters. In fact, variable-speed belt conveyors use up to 20 percent less electricity, especially in view of the fact that they function as regular motors as well as generators. In all operating scenarios, a frequency-controlled drive can be adjusted for optimal torque and optimal speed, which means it can be accelerated more smoothly and without any jerking. This type of operation goes easy on the drives, bearings, belt pulleys, brakes and rolls, and avoids belt vibration and tears.

Belt conveyor project at Vattenfall Mining Europe

Time and again, experience gained during operation proves to be an important source of inspiration for the further improvement of different components in a belt conveyor. The case is no different with the belt conveyor at Vattenfall Mining Europe’s Reichwalde open-pit mine. Here, the operator and planners met at an early stage and got the requirements down in writing.

Vattenfall – Europe’s fifth-largest electricity producer and the leading heat supplier – excavates lignite coal in
different open-pit mines in the east of Germany. The mines are among the most sophisticated in regard to system engineering. Around 60 million tons of lignite coal are turned into electricity at the Jänschwalde, Schwarze Pumpe and Boxberg power plants. To ensure a steady supply of coal for the Boxberg power plant, starting in 2010 coal excavation was resumed in the Reichwalde open-pit mine.

To transport the lignite coal, Siemens supplied a belt conveyor system with a total length of 13.5 km. With a width of 2,000 mm, the conveyor belt can transport around 6,000 tons per hour. The system includes six conveyor flights with a total power requirement of 19,350 kW: three drive stations have drives with a rating of 1,250 kW each, and three with 900 kW each. Four of the belt conveyors are stationary and two are shiftable.

Vattenfall poured its experience gained over the years – in mechanical as well as electrical engineering – into a complex package of requirements to be implemented in the new conveyor, in particular with the help of modern drive systems. In all six drive stations, modern variable frequency drive systems based on the Sinamics S120 converter were installed. These very compact inverters run in four-quadrant operation and feed the energy generated during braking back into the grid. In the following, the many options for a tailored, multi-motor drive solution are described.

Load-dependent conveyor belt speed

The loading capacity of a belt conveyor can often change, for example as a result of conditions in an individual layer or the number of coal excavators at work. Therefore, from an economic as well as an ecological standpoint, it makes sense to adjust the conveyor speed to the current volume. A reduction in speed at lower average loads means fewer belt circulations and thereby less wear. This type of operation prolongs the service life of components such as bearings, load-bearing rollers and motors, and reduces energy use. The Siemens control function is set up so that load is measured on the first belt conveyor that functions with constant speed, and the speed for the following belt conveyors is adjusted accordingly.

The operational mode described above has the additional advantage that with the change in the conveyor speed, the trajectory parabola on the hand-over point changes, and as a result, so too does the point of impact in the transfer chute. This means that a larger area is exposed to wear – in contrast to wear on one specific point, which is typical for a conveyor belt operating at a constant speed. The lifetimes of the individual plates are therefore higher.

Optimized start-up and stopping

A comparison of the start-up process of a belt conveyor with and without a controller reveals considerable differences: In an uncontrolled system, the individual belt conveyors are started one after the other. This means that for every start-up there are several minutes of unproductive time until the entire facility is up and running, and material can be transported. This type of start-up is necessary to prevent overflows at the transfer points. Speed-controlled drives allow individual belt conveyors – independent of their load – to be started up or stopped at the same time. Efficiency is improved with drive control. This mode of operation has been used in many Vattenfall conveyors, and has also been integrated in the new coal conveyor.

Furthermore, a gentle start-up of the belt conveyor avoids mechanical peak loads on the belt. The converter changes the speed and torque according to a defined ramp. These peak loads from non-steady-state operation also impact the dimensions of the components. If peak loads are avoided, a
belt with a lower tensile strength can be used, which considerably reduces the investment costs. At the same time, optimization of the start-up, especially in the non-steady-state periods, can stop the conveyor belt from lifting up in certain areas, which prevents further peak loads during start-up. This is especially important, since the topography in the Reichwalde open-pit mine with its many concave sections poses a particular challenge.

In normal operations, with the help of the converter and the defined ramp, the belt conveyor is stopped. Consequently, the brakes are not used, which translates into a considerably higher lifetime for the brake pads. The brakes are therefore only designed for emergency situations. In normal operations they are employed at about 5 percent of the nominal speed. This is necessary to avoid the brakes from rusting. In effect, the brakes have the function of a holding brake.

**Improvement in dynamic behavior**

With longer belt conveyors, especially during start-up, translatory vibrations often occur. These vibrations represent a high additional load for the entire facility. With a variable drive, the start-up ramp can be designed so that there are no translatory vibrations.

During commissioning, Siemens engineers measured the natural frequency and other resonant frequencies to ensure that the entire facility is not operating in a critical speed range. The measurements showed that there was no resonance in the intended speed range. Otherwise, the drive would have to be protected and the relevant speed range quickly passed. The converter offers the respective system functions.

Along with the described impact on operations, the use of converter technology results in other effects that allow for better system dimensioning, require lower dynamic ranges and reduce mechanical stress. For example, slippage between the drive pulley and the belt can be reduced when the implemented drive control software compares the speed of non-driven pulleys with the speed of the drive pulleys. If differences are detected, a signal is sent to the drive, which either increases its speed or brakes, thereby avoiding relative motion between the belt pulley and the conveyor belt.

**Load distribution in multi-drive pulley operation**

In this project, multi-drive pulleys were used. Minimal differences in the average diameter of the pulley – as a result of production tolerances and wear – can result in speed differences between the drive pulleys. The consequence is relative motion between the conveyor belt and the drive pulley. This type of relative motion always leads to increased wear on the pulley laggings. The drive control software now monitors the load distribution and compensates deviation so that the required performance corresponds precisely to the respective drum shaft and to the previously planned ratio. In general, the ratio between drive pulley 1 and drive pulley 2 is 1:1, though other ratios, for example 1.1:0.9 are possible. This enables exact settings. At Vattenfall, two drives work on drive pulley 1. As described above, these drives are monitored and regulated according to the load distribution. In this way, overloads on individual drive components and the transfer of inadmissible peaks on the conveyor belt are avoided. This increases the lifetime of pulleys and friction linings.

**Project experience**

Siemens handed the coal conveyor systems over to Vattenfall Mining AG after six months of trial operation. The operators’ expectations in regard to functionality and operational performance were thoroughly fulfilled.

The many years of good collaboration between Vattenfall and Siemens have resulted in one of the world’s most advanced belt conveyors at the Lusatian lignite coalfield. Siemens integrated the new facility in the existing control center, from where the two complete open-pit mines, transport of coal from the mines to the stockyard, and all the logistics at the stockyard can be monitored and controlled. The Boxberg power plant is fed with coal from the stockyard, and rail loading facilities can supply other power plants in the Lusatian area.

Integration in the control center ensures better access to plant parameters and a secure, detailed history, which builds the basis for the design of future belt conveyors.