Steel-Cord Conveyor Belt Splices—More than Tough Enough
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The introduction of steel cord conveyor belts more than 50 years ago revolutionized conveyor technology. Since then, increasingly longer conveyors, higher loads and more complex routing have become possible, with no end to these advances in sight. Because every conveyor has one or more individual belt sections that must be spliced to make an endless conveyor belt, this record of success has relied heavily on splicing technology. This article describes experience that has been gathered with steel cord conveyor belt splices in various application fields in opencast and underground mining.

Steel cords are susceptible to corrosion. Previously, stainless steel cords were used in some very acidic environments underground, but were never able to achieve complete success due to their high price and low specific strength.

In some earlier steel-cord belt applications, moisture could come into contact with a cord if the belt was damaged and then could spread along the cord like water in a drinking straw. In extreme cases corrosion pockets, invisible from the outside, developed several hundred meters away from the damaged section. This was even more likely to occur at the splice, where the cords had open ends.

In addition, the splice ramps were often torn open by belt scrapers, making it easier for dirt and water to penetrate the belt, resulting in delamination and rust in the splice, and at worst, torn splices.

Presently, corrosion is no longer a problem with top-class steel cord conveyor belts—even when they have exterior damage—due to the use of high quality, hot-galvanized cords of a special open design, combined with special rubber compounds and state-of-the-art production technology. These materials and modern processes, as well as additional protection provided by cascaded ramps and synthetic traverse cord reinforcement, present numerous advantages for the splices, including resistance to corrosion. Most importantly, splices made using the latest technology can last as long as the entire conveyor belt, even exceeding 30 years on very long conveyors.

Splice Specifics

In general, the splice is considered to be the weakest point in an endless conveyor belt. Statically, it is usually easy to achieve a tensile strength that corresponds to that of the belt. In other words, it takes roughly just as much force to pull apart the splice as it does to tear the belt. For optimum belt configuration
and dependable continuous operation, however, another parameter is vital: the dynamic efficiency of the splice. For many years now, all major conveyor installations have been evaluated and configured based upon this criterion.

The fatigue strength of the splice is determined in accordance with section 3 of the DIN 22110 standard. Four endless belts, 18 m long and at least 250 mm wide, are placed on a test conveyor, one after the other. This test machine is located at the ITA Institute of the University of Hanover in Germany.

The belts are run until they break or at least until the reference number of 10,000 load cycles has been achieved. During each saw-tooth patterned load cycle, the belt travels over the two drums 18 times. Running the test longer would not result in any additional findings. The upper load is specified such that a specimen breaks after achieving a high number of load cycles and another specimen runs through at least until it has reached the reference load cycle number. A Wöhler (endurance) curve is created with the results for the four test belts. The dynamic efficiency of the splice is calculated from the maximum top load, at which the 10,000 load alternations are achieved.

In the DIN 22101 standard, which has been in effect since 2002, the dynamic efficiency is taken directly into account when specifying the necessary belt tensile strength. In general, a high dynamic efficiency of the splice lowers the belt's tensile strength. This contributes substantially to further improving the cost efficiency of conveyors with steel cord conveyor belts.

Pipe conveyor belts are subjected to higher loads than troughed conveyor belts, since there is much higher tension along the edges during the flat-to-trough and trough-to-flat transitions. This must be taken into account when specifying the belt breaking strength.

**Theory...and Practice**

Finite element programs are used to theoretically develop optimum splice geometry. In simple terms, it is a matter of positioning the cords in combination with the components and materials used such that the forces are distributed as uniformly as possible across the entire splice area.

However, it is important that the splice technology is not compromised when carried out in practice. This requires that there is an air-conditioned, dust-free assembly hall with a modern vulcanization device, that fresh and suitable (unvulcanized) splice material is used, and that experienced engineers and
splicers carry out the work in accordance with the instructions from the conveyor belt manufacturer.

An investigation following a tragic accident in a South American copper mine actually illustrated that excellent results can be achieved when splicing is correctly performed on-site. External factors caused a mine tunnel to collapse in which a Phoenocord St 6800 conveyor belt was being used. The collapse was so powerful that the running conveyor belt, which has a breaking strength of 10,000 kN, tore abruptly—not directly at the splice, but several meters away from it.

The nearest splice was cut from the belt and sent to ITA for assessment. The findings were reassuring: The splice demonstrated the same dynamic efficiency as the test splices made in the project phase. The splice did not suffer, despite the splicing conditions on-site, aging, and the extreme tensile forces caused by the collapse of the tunnel. Meantime the remaining splices have been successfully in use for 15 years.

In 1999, the world’s strongest conveyor belt, a Phoenocord St 7800, was installed with the world’s strongest splices in a 23-km conveyor system that transports 8,700 mt/h of copper ore from the Los Pelambres mine in the Chilean Andes to the concentrator. The splices are approximately 7 long and have a dynamic efficiency of 54%.

In addition to the Phoenotec damage protection within the belt (illustration) and the Phoenocare SL rip detection (illustration), the Phoenocare-SC splice monitoring system (illustration) was used for the first time because of the importance of this conveyor system. This splice monitoring system has external sensors that constantly monitor the length of all splices using magnets that are permanently vulcanized into the splice. External factors such as belt speed, temperature and load are also processed in the calculations. If the splice length changes, exceeding a tight tolerance, an alarm is triggered or the conveyor belt is automatically shut down.

**Experience Underground**

In the mid-1970s, German safety regulations for mining were tightened substantially. Since that time, only self-extinguishing conveyor belts may be used in underground coal mining. In the case of steel cord conveyor belts (DIN 22121), this requires that the cover and core rubber used be based upon chloroprene rubber (CR). Accordingly, the splices must also be constructed with CR, which required a new splice design because of its molecular structure which deviates
from the usual SBR/NR compounds and the vulcanization process—CR cannot be vulcanized with sulfur.

Since 1976, hundreds of steel cord conveyor belt splices have been fabricated on CR belts. This trend reached a peak in 1986 with the strongest underground conveyor belt to date, the Phoenocord St 7500. This belt in the Prosper-Haniel underground mining complex (illustration) was made with the longest and strongest splices in use underground. The four-step splice is 6.5 m long (illustration).

Besides the ongoing optimization of the dynamic efficiency of all classes, our next step is the practical application of a conveyor belt above and beyond the Phoenocord St 7800. In the interest of the mining industry, the efficiency and reliability of steel cord conveyor belts and their splices should be increased even further.

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