St 10,000 – a new development in high-tension conveyor belt design

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Introduction

The introduction of steel cord conveyor belts some 60 years ago revolutionized conveyor technology. Since then, increasing longer conveyors, higher loads and more complex routing have become possible, with conveyor belt ratings that were unthinkable only a few decades ago. The highest rating available now is the St 10,000, developed by Phoenix.

The background

Looking back 40 years, the strongest belt was a Phoenocord St 4,000 used in an underground coal mine in Europe. St 4,000 stands for a minimum breaking strength of 4,000 Newtons per millimetre of belt width.

15 years later, a Phoenocord St 5,400 was supplied for the German hard coal mining group RAG. Like the St 4,000 it was for a slope conveyor, carrying coal from underground straight to the surface.

Another 10 years later, St 6,300 belts were used on bucket wheel excavators in German brown coal mining. These giants were 3,200 mm wide, having a total belt strength of some 22,000 kN resp. 2,200 tons. They are carrying up to 40,000 tons of bulk material per hour.

Then, in 1986, 26 years ago, the world’s strongest conveyor belt, a Phoenocord St 7,800, was commissioned. It carries coarse copper ore downhill from a mine elevated at 3,200m above sea level. The system is approximately 13 km long and consists of three flights, of which the top two are equipped with the St 7,800. The total drop is 1.3 km (see Figure 2.)

Almost the complete length is working in tunnels. Even the transfer stations are inside buildings.

The belt carries 11,000 t/h at a speed of 6.8 m/s downhill and hence is not consuming but generating power: The belt feeds the concentrator with more than 100 million kW-hours per year.

All of the above mentioned conveyor belts are specially protected with the Phoenotec integral active system consisting of transverse synthetic single cords, which increases their resistance against impact and rip damage (see figure 7).

Now, even the St 7,800, having an actual breaking strength of more than 8,600 N/mm, is not the end. Phoenix has made another step and developed the Phoenocord St 10,000. It is ready for use now.

Why St 10,000?

To visualize the magnitude of an St 10,000: Seven Airbus A 380 Super Jumbo Jets could be hung on a 2,000 mm wide St 10,000 – and it would not tear (see Figure 3).

The advantages of such a belt are longer conveying distances and reduction of the number of transfer points. This reduces the wear of the belt, bringing down investments and maintenance expenses, and increasing availability.

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Distances that have been reserved for other means of haulage can now be managed with belt conveyor systems.

Development and production aspects

When developing these high-end conveyor belts, a focus is always on the splice, because the splices are naturally the weakest parts of a conveyor belt.

An overland conveyor belt is shipped in several single lengths. Every reel represents one splice to be done at site. Although single reels with a weight of 60 tons and more are feasible, flights of say 50 km still would require some 300 reels resp. splices.

In a splice, all the forces are transmitted by the rubber. No steel cord is directly connected to another steel cord. It is obvious that they have to be done with utmost care. 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.

Simple configurations like the one-step pattern can be employed for low-strength belts. However, for the St 7,800, with the strongest splices worldwide, we had to design a 5-step pattern in order to have enough rubber between the cables for the force transmission (see Figure 4). The worsening ratio of cord pitch versus cord diameter becomes obvious when comparing a belt cross-section of an St 1,000 and an St 10,000 (see Figure 5).

An important contribution to the splice efficiency - and of course to the robustness and longevity of the entire conveyor belt - is the complete penetration of the steel cords with a specific...
low viscosity adhesion rubber into the big steel cables. To assess the bonding between the steel cords and the rubber, dynamic pull-out strength tests as well as air permeability tests are being carried out.

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, the major conveyor installations have been evaluated and configured based upon this criterion.

The dynamic efficiency resp. fatigue strength of the splice is determined in accordance with section 3 of the DIN 22110 standard. The official test is administered at the ITA Institute of University of Hanover. Four endless belts are placed on a test conveyor, one after the other. 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.

For belt splices of higher than St 7,800, for instance St 10,000, a new machine with a maximum tension of 2 x 3,500 kN was installed at the ITA Institute two years ago (see Figure 6). This machine has a weight of 250 t.

The nearest splice was cut from the belt and sent to ITA institute 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 of this 19.6 km long belt have been successfully in use for 17 years.

If specific rules are followed, the splices will last as long as the belt; which can be up to 40 years under certain conditions.

Conclusion

Decades of R&D and practical experience with the then prevailing strongest conveyor belts have led to the new Phoenocord St 10,000. It has been tested thoroughly, including the important official dynamic splice efficiency. Projects are being discussed for its implementation.

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