Aramids in conveyor belts:
a strong, energy-saving alternative

Minerals on the move

Most minerals travel a long way from their point of extraction to their point of use. Typically, this journey involves trucks, conveyor belts, trains and/or boats. For short haul distances, truck transport offers a flexible solution. But trucks are heavy and require a lot of fuel. As a result, there has been a noticeable shift towards conveyor transport. What is more, distances within mines are typically increasing, because the longer a mine is in operation, the further away extraction moves from the processing point (such as a power plant built next to a coal deposit). In fact, longer haul distances are one of the reasons that energy use in mines is increasing globally by 6% per year. It is not surprising, therefore, that mines are looking for ways to counter the associated increase in energy cost. An additional challenge mines are facing relates to their licence to operate from society. People are increasingly critical about the use of fossil energy and carbon emissions. In this article, we focus on the transport of minerals on conveyor belts and how the use of aramids can help to reduce the energy used by such belt conveyors.
Reinforcing conveyor belts

About a century ago, the first conveyor belts were small, and at that time, rubbers were typically reinforced with cotton. Today, natural cotton fibre has been replaced by modern man-made materials, such as polyester (PET) and polyamide (PA). These materials are light, strong, resilient and abundantly available. However, they have one serious drawback: low stiffness modulus. Long belts have extreme elongations. A 5-km conveyor installation, for example, has a 10-km looped belt. If this belt elongates by 3% under running tension, 300m of excess belt length is formed, which needs to be taken up. That is why long belts are normally reinforced with steel, in the form of embedded cables. However, steel not only has high modulus, it is also characterised by a substantial density (7.8 kg/L). In any moving system, more weight means more energy consumption. So, are there any solutions that can help lower the weight of conveyor systems?

Aramids – as strong as steel but five times lighter

Aramid fibres may embody the perfect solution to this problem. The name aramid derives from aromatic polyamide. Like any man-made high-strength fibre, its strength is achieved by carefully aligning strong molecular chains along the direction of the force. The result is a fibre that is almost as strong as steel, but a lot lighter. Aramid fibres have a density of just 1.45 kg/L – five times lighter than steel. Aramids are also three times stronger than polyester, which is also a frequently used as a reinforcement material in conveyor belts. Figure 1 below compares the tenacity and elongation of steel with that of three man-made fibres.

Since the 1970s, aramids have been used for a wide range of applications requiring high strength, high modulus and low weight. Their use in ballistic protection is particularly well-known, such as in bullet-proof vests (which need to be light for comfortable wearing), and in lightweight ballistic shields for moving vehicles or aircrafts. Less visible but equally widespread is the use of aramids to reinforce car engine hoses: aramids can easily withstand the heat, chemicals and vibration around a car engine. In addition, aramids are used to reinforce drive belts (which require high strength and fatigue resistance for long life) and brake pads (in which heat-resistant aramid replaces carcinogenic asbestos).

When aramid is used in a conveyor belt, the whole system weight can be reduced substantially. This has been verified by Professor Gabriel Lodewijks of Delft Technical University in the Netherlands. Professor Lodewijks calculated this weight reduction in an existing conveyor belt installation in South Africa, used to transport coal from the mine to a power plant. This installation, which uses steel-cable-reinforced belts, was recalculated for comparison with aramid-reinforced belts. The results speak for themselves: the use of aramid would reduce the belt weight from 32 to 19 kg/m, which would mean that the system weight of the carrying belt, the coal load and the empty belt on the return side would be reduced from 170 to 144 kg/m. This is equivalent to 15% less moving mass.
Rolling resistance

On a long conveyor belt, more than 60% of driving energy is lost by indentation rolling resistance (see Figure 3). This is the hysteresis loss when a rubber belt passes over its support rollers and deforms.

Sulfron, an aramid-based rubber ingredient produced by Teijin Aramid, offers a solution to this problem. When used in the rubber running layer of a conveyor belt, Sulfron lowers hysteresis. In the same study by Professor Lodewijks, Sulfron was included in the belt drive power calculation. The combination of low-weight aramid reinforcement and less rubber rolling resistance was shown to reduce belt power consumption by an impressive 25%.

So how relevant is this saving? The South African installation covers a distance of 15km with 4 conveyor belts. Under full load, the energy usage is the equivalent to the daily consumption of a town with 20,000 inhabitants. The energy saving on just one large conveyor installation is therefore equivalent to the domestic electricity use of 5,000 people. And this saving is 24/7. At the end of the year, it adds up to savings on the energy bill of hundreds of thousands of dollars for this single conveyor operation.
Aramid belts in practice

The above example was just a calculation. Let us next consider some practical cases. There are quite a few short aramid belts already in operation around the world, as well as some long-distance ones. One example is a 2.6-km belt at the Maritsa Istok-2 power plant in Bulgaria. An important design consideration for the installation was low power consumption. This pipe conveyor (closed belt against spillage) with steel reinforcement was estimated to be 44 kg/m. By reinforcing it with aramid, belt weight was reduced to 29 kg/m. This meant the moving system weight was reduced from 162 kg/m to 132 kg/m (carrying belt + payload + returning belt), which is 18% less moving mass. In simplified form, resistance is linear, so approx. 18% less power is needed to drive the fully loaded belt. The 2.6-km aramid-reinforced pipe conveyor has been running since 2000 without any problem, and in 2007 it was decided to install a second aramid belt of 5.8-km, which became operational in early 2009.

A second example of an installation in which steel was successfully replaced with aramid can be found at the Compagnie des Phosphates de Gafsa (CPG) phosphate mining operation in the Gafsa basin, Tunisia. Two installations, with lengths of 3-km and 4-km respectively, originally ran with a 1m-wide steel-reinforced belt. To improve corrosion resistance, the steel belt was replaced with a fabric-reinforced belt in 2000. The available take-up length of the installation was sufficient for a replacement with aramid-reinforced belts with low elongation. After 10 years of successful operation, in June 2010, the belts needed replacement because of rubber wear and they were replaced with new aramid-reinforced belts.
Moving forward

Measuring the exact energy consumption of a conveyor belt is complicated. Drive power changes over time, with belt load, operating temperature, belt speed and other factors all playing their part. Belt weight is easy to determine and can be straightforwardly linked to energy use. However, when it comes to rolling resistance, it is much harder to arrive at a clear energy saving figure. To generate more data, several installations in e.g. coal mines are planned or being installed which will be closely monitored for energy use.

Mine operators are obviously keen to prevent installation downtime, which is why alternative belt reinforcement will only be considered if reliability is proven. This is particularly important in the case of long conveyor belts, which are assembled from individual rubber belt sections of several hundred metres each. The weakest parts of these belts are the connection points (splices) where the various sections are joined up.

In order to prove reliability, splicing company SMC Industrial made splices, which are currently being tested on dynamic strength at the University of Hannover in Germany. This testing is being performed in accordance with DIN standards, in which repetitive stress is applied that represents the forces on an operating belt. In practice, aramid belts have a long track record for reliability and these tests will undoubtedly add up-to-date, reliable and extensive splice strength data. This should lead to the wider acceptance of aramids in conveyor belts, and greater appreciation of the fact that their low weight can substantially reduce energy costs and make mineral conveying more sustainable.

References
Lodewijks, G., The next generation low loss conveyor belts, Bulk Solids Handling, No 1, 2012
Bos, H., Twaron – losing weight around your (conveyor) belt, presented at Teijin Aramid’s 5th European Conference on the Use of Aramids as Elastomer Reinforcement, Amsterdam 2010
Arts, K., Aramid reinforced conveyor belt in Maritsa Istok 2 power plant – a case study, presented at BeltCon 15 Conference, Johannesburg 2009
Metso Minerals, Trellex Aramid Conveyor Belts, company presentation, Moers 2002

More information
For more information please contact:
Henk van de Ven
Sales Account Manager Elastomer Reinforcements, Teijin Aramid B.V.
henk.vandeven@teijinaramid.com

About Teijin Aramid
We are Teijin Aramid, a subsidiary of the Teijin Group with a passion for aramid. Our commitment both to our products and to our customers has made us a global leader in aramids. Wherever strength, safety, heat or flame resistance, low weight or sustainability is required, you will find our Twaron®, Sulfron®, Teijinconex® or Technora®. Our products are used worldwide in many different applications and markets, including automotive, ballistic protection, marine, civil engineering, protective clothing, optical fiber cables, and oil & gas. With our four high performance aramids – produced at our plants in The Netherlands and Japan – we offer the widest range of products. And, with unrivalled expertise and experience we are able to continuously work on further innovations. Often in cooperation with customers and partners through our worldwide sales and marketing organization. That’s the power of aramid. If you would like to learn more about the world of aramid or to exchange ideas on developing new solutions, please go to www.teijinaramid.com.