TOO SOON ON THE SCRAPHEAP?

Leslie David, Conveyor Belt Specialist, describes the causes and effects of conveyor belt wear and tear, as well as the reasons why there are such huge disparities in operational lifetime and durability between one manufacturer and another.

The wear and tear that takes place on the outer covers of rubber conveyor belts is commonly referred to using the umbrella term 'abrasion'. However, there is more to the wearing process than simply abrasive wear. As a general rule, 80% of conveyor belt surface wear occurs on the top cover of the belt with approximately 20% of wear on the bottom cover. Wear on the top cover is primarily caused by two actions.

First and foremost is the abrasive action of the materials being conveyed, especially at the loading point or 'station' and at the discharge point where the material is effectively 'accelerated' across the belt surface. This kind of abrasion is particularly associated with 'fine' materials, such as sand or gravel, which literally act like a piece of coarse sandpaper constantly scouring the rubber cover.

Cutting and gouging

A second major contributor to wear and tear is the cutting and gouging of the rubber surface caused by materials that have sharp edges such as larger, coarser aggregates and rocks. Again, this largely occurs at the loading and discharge points. The heavier and sharper the material, the greater the damage it can cause, especially if loaded from height. It is important to bear in mind that the ability of a belt cover to withstand wear is not only due to its 'abrasion resistance', because much also depends on the cover rubber's overall strength and its resistance to cut and tear propagation. If that resistance is low, then a small, seemingly insignificant area of damage in the cover can easily increase in size due to the continuous material loading and the relentless flexing around the drums and pulleys. In time, this damage will spread and link up with another area of damage. Consequently, small pieces of damaged rubber are effectively cut out from the surface rather than being simply worn thinner.

Wear on the bottom cover of the belt is mainly caused by the friction contact with the drum surface and idlers. The rate and uniformity of this type of wear can be adversely affected by other factors, such as misaligned or worn drums and idlers set at incorrect angles or an unclean environment. Belt cleaning systems, especially steel-edged scrapers, can also cause wear to the top cover surface.

An invisible cause of premature wear

There are also two other 'invisible' but highly destructive and vastly underrated forces: ozone and ultraviolet light.

Ozone

Ozone (O_3) occurs naturally in the upper atmosphere. It is continuously formed by the action of solar ultraviolet radiation on molecular oxygen (O_2). At high altitude, ozone acts as a protective shield by absorbing harmful ultraviolet rays. Wind currents carry O_3 to the atmosphere at the Earth's surface. However, at low altitude, ozone becomes a pollutant. Ground-level or 'bad' ozone is created by the photolysis of nitrogen dioxide (NO_2) from sources such as automobile exhaust and industrial discharges, and is known as ozonolysis.

Figure 1. Abrasive material is effectively 'accelerated' across the belt surface.

Figure 2. The cracks are always oriented at right angles to the strain axis.

Figure 3. Pollution problems – fine particles of dust penetrate the cracks and are then shaken out on the return run of the belt.

Ozonolysis causes cracks to form in rubber that is under tension. The cracks are always oriented at right angles to the strain axis. The dynamic stress that a conveyor belt undergoes while in operation is considerable and ozone attack occurs at the points where the strain is greatest.

The mechanical stress, combined with the friction created between drums and idlers, activates an oxidation process causing the rubber to become brittle, lose strength, and increasingly unable to withstand abrasive wear.

Ultraviolet light

Ultraviolet light from sunlight and artificial (fluorescent) lighting accelerates rubber deterioration because it produces photochemical reactions that also promote the oxidation of the rubber surface, resulting in a loss in mechanical strength. This is known as 'UV degradation'.

The problem is ever-present even in the most moderate of environments. The combined effect of the ozonolysis and UV degradation means that cracks steadily grow until catastrophic failure occurs. Over time, the repair of splices also becomes increasingly difficult as the adhesion properties of the rubber diminish.

Yet another problem is that moisture seeps into the cracks and penetrates down into the belt carcass. In multi-ply belts, the fibres of the weft strands of the plies expand as they absorb the moisture. This in turn causes sections of the carcass to contract (shorten), as the weft strands pull on the warp strands of the ply, which can result in tracking problems that can be very difficult to pinpoint.

Fortunately, almost complete protection against the catalogue of problems caused by ozone and ultraviolet is relatively easy to achieve by using antioxidants within the rubber compound. Unfortunately for end-users, however, laboratory testing reveals that some 90% of belts sold in Europe, Asia, and Africa have virtually no protection, the reason for which will be explained later.

Selecting the right cover grade: Abrasion standards and test methods

The two most commonly referenced standards for fabric reinforced belting are the international ISO 14890 (with abrasion resistant classes H, D, and L) and German DIN 22102 (with abrasion resistant classes Y, W, and X). In Europe the longer-established DIN 22102 standard is still very often used, although the most current version of this standard references the ISO 14890 on most topics, making both more or less identical. Generally speaking, the DIN grade 'Y' (or ISO 14890 closest equivalent grade 'L') relates to 'normal' service conditions and DIN grade 'W' (close to ISO 14890 grade 'D') for particularly high levels of abrasive wear. DIN grade 'X' (close to ISO 14890 grade 'H') is regarded as the most versatile because in addition to resisting abrasive wear, it also has good resistance to cutting, impact (from high drop heights), and gouging caused by heavy, sharp materials. To achieve these characteristics, the rubber compound needs to contain a higher than usual element of natural rubber (NR), and is therefore the higher priced option.

The test method for abrasion (ISO 4649 / DIN 53516) is quite simple. Abrasion resistance is measured by moving a test piece

of rubber across the surface of an abrasive sheet mounted on a revolving drum. It is expressed as volume loss in cubic millimetres, for instance 150 mm^3. It is important to remember when comparing abrasion test results (or promises) that higher figures represent a greater loss of surface rubber, which means that there is a lower resistance to abrasion. Conversely, the lower the figure, the better the wear resistance.

Thicker is not always better

As a rule, the difference in thickness between the top cover and the bottom cover should not exceed a ratio of more than 3 to 1. However, in an attempt to extend operational lifetime, many conveyor belt users resort to fitting belts with extra thick covers. This is often a mistake, because covers that are too thick can cause other problems. The fact is that the most important factor is the ability of the rubber to withstand abrasion, cutting, gouging, and exposure to ozone and ultraviolet, and it is here that the reasons for the enormous differences in durability and longevity can be found.

It is all about the quality of the rubber

The conveyor belt market is hugely competitive. As a result, price is invariably the number one purchasing criteria. Rubber forms some 70% of the volume mass of a conveyor belt and more than 50% of the cost, so it represents the biggest opportunity for manufacturers to achieve price competitiveness. It is therefore not surprising that the primary cause of rapid belt cover wear is low-grade 'economy' rubber that has inadequate resistance to abrasive wear and cutting rather than rubber that has been engineered to provide a high level of resistance. This is also the reason for the huge disparities between one manufacturer and another in terms of price.

Cost cutting: How it is achieved

Because of its adaptability, most of the rubber used to make conveyor belts is synthetic. Dozens of different chemical components and substances are used to create rubber compounds that can cope with the demands placed upon them. These chemical components and additives are very costly, so a combination of using low-grade, unregulated chemicals at the absolute minimum levels (or in some cases not using them) all contributes towards the manufacturer's 'lowest possible price' objective. Perhaps the best example of these omissions are the antioxidants needed to protect against ozone and ultraviolet light exposure. They are regarded by most manufacturers as an avoidable cost, which explains why, as stated earlier, some 90% of belts sold in Europe, Asia, and Africa have virtually no ozone or UV protection.

Despite the crucial role that it plays, yet another cost-cutting opportunity involving the rubber is carbon black polymer, which is a key component and makes up around 20% of a typical rubber compound. For example, carbon black prolongs belt life by slowing the ageing

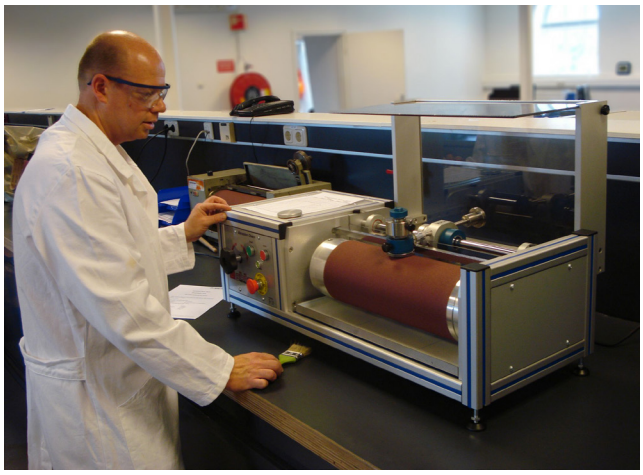

Figure 4. ISO 4649 / DIN 53516 abrasion testing.

Figure 5. Cost-cutting opportunity – rubber represents 50% of the cost of making a conveyor belt.

process. It also acts as an important reinforcing compound. Good-quality carbon black is costly, so belts offered with significantly lower prices are virtually certain to contain low-grade carbon black, which is most likely to have been made by burning scrap car tyres rather than the much more complex, scientific methods used to make good-quality carbon black.

A clue to the use of poor-grade carbon black is often a strong, pungent smell, whereas good-quality rubber should have little or no smell at all. Much more seriously, low-grade carbon black can contain carcinogenic chemical residues that are dangerous for people and the environment.

A direct connection

The huge disparities in operational lifetime and durability between one manufacturer and another are mirrored by equally huge disparities in price. The connection, of course, is no coincidence. As with most products, the price reflects the quality. To quote the old saying, price is what you pay, but cost is what you spend. The mathematics regarding cost are simple – belts that last appreciably longer and require less intervention cost much less. GMR