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Invisible conveyor belt destroyers

How ozone and ultraviolet light are dramatically shortening the working life of your cement plant's conveyor belts...

There are an awful lot of things that damage conveyor belts in cement plants. The constant abrasive action of material being loaded at speed onto the belt and then being accelerated across its surface at the discharge point; the hammering that the belt surface and its carcass takes as aggressive materials (often sharp and heavy) are dropped onto it; the ripping and tearing that occurs when rocks or foreign objects become trapped; the softening and distortion of the rubber caused by oils and resins; the hardening and premature ageing of the rubber caused by heat. The list goes on and on.

All of these factors are, of course, very well known to operators of conveyors. The fact that conveyor belts can be engineered to significantly limit the amount of damage each of these factors can cause is also pretty common knowledge. However, what is definitely not common knowledge within the world of industrial conveyor belts is that there are also two other 'invisible' and inescapable factors that cause very serious damage on a daily basis. During operation of the belt they rapidly shorten its operational life. They are ozone (O_3) and ultraviolet light (UV).

If you type *'The effects of ozone on rubber conveyor belts'* into your search engine then only one belt manufacturer's name appears - Dunlop Conveyor Belting in the Netherlands. This article explains the little known effects that O_3 and UV have on conveyor belt lifetimes, their vastly underrated consequences and how to avoid them.

From protector to destroyer

Ozone (O_3) occurs naturally in the upper atmosphere, where it is formed continuously by the action of solar ultraviolet radiation on molecular oxygen (O_2). At high altitudes, O_3 acts as a protective shield by absorbing harmful UV rays. Wind currents carry O_3 to the atmosphere at the Earth's surface.

At low altitude, O_3 becomes a pollutant. Ground level or 'bad' ozone is not emitted directly into the air, but is created by the photolysis of nitrogen dioxide (NO_2) from vehicle exhausts and industrial discharges. The effects are known as ozonolysis.

The variability of weather, airflow patterns, seasonal changes, vehicle and industrial emissions, geographical and climatic conditions such as higher altitudes and coastal areas mean that ozone concentrations (and therefore the level of exposure) can differ greatly from one location to another. That said, ground level ozone pollution is an ever-present fact of life that must never be under-estimated.

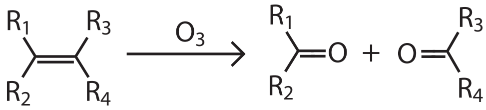
Even tiny traces of ozone in the air will attack the molecular structure in rubber. Ozone also increases the acidity of carbon black surfaces, with natural rubber, polybutadiene, styrene-butadiene rubber and nitrile rubber being the most sensitive to degradation. This can have several consequences such as surface cracking and a marked decrease in the tensile strength of the rubber.

Right: Ozone cracking accelerates heat damage.

Right: An EN/ISO 1431 test sample shows cracking caused by ozone.

Ozonolysis

Ozonolysis is the reaction that occurs between the double bonds in the molecular structure of the rubber and ozone...



The immediate result is formation of an ozonide, which then decomposes rapidly so that the double bond molecule is split. The critical step in the breakdown of molecular chains is when polymers are attacked. The strength of polymers depends on the chain molecular weight or degree of polymerisation. The longer the chain length, the greater the mechanical strength, including the highly important tensile strength. By splitting the double bond chain, the molecular weight drops rapidly. There comes a point when it has little strength remaining and a crack forms. Further attacks occur in the freshly exposed cracks, which continue to steadily grow until they complete a 'circuit' and the product separates or fails.

A partner in crime

To make matters worse, low-level ozone has a partner in crime that also has a seriously detrimental effect on rubber. UV light from sunlight and fluorescent lighting accelerates rubber deterioration because it produces photochemical reactions that promote the oxidation of the rubber surface. This also results in a loss in mechanical strength. The effect is known as UV degradation.

Unfortunately, the decline in the ozone layer in the upper atmosphere in recent decades now allows an increasing level of UV radiation to reach the earth's surface. Continuous exposure is a more serious problem than intermittent exposure, since attack is dependent on the extent of exposure. As one might expect, the problem is exacerbated in sunnier, hot climates but even in the most moderate of environments, the problem is nonetheless ever-present.

Hidden effects

Ozone cracks form in rubber that is under tension. However, the critical strain needed is only very small. Even a belt that is not fitted on a conveyor has a certain amount of intrinsic tension. The cracks are always oriented at right angles to the strain axis. Ozone attack will occur at the points where the strain is greatest and the rubber is flexing in use. Splice joints are particularly prone to stress concentrations.

At first glance, fine cracks in the surface rubber may not seem to be a major problem. However, over a period of time the rubber becomes increasingly brittle. Transversal cracks deepen under the repeated stress of passing over the pulleys and drums. The ozone continues to attack, so the cracks steadily grow until catastrophic failure occurs. Again, surface cracking may not initially seem to be a cause of concern, but there are often other potential risks such as scrapers catching on the cracks and tearing off parts of the cover. Re-splicing can also become more and more difficult as the adhesion properties of the rubber diminish.

Yet another 'hidden' problem is that moisture seeps into the cracks. This then penetrates down to the actual carcass of the belt. In multi-ply belts, the fibres of the weft strands of the plies expand as they absorb the moisture, which in turn causes sections of the carcass to contract (shorten) as the weft strands pull on the warp strands of the ply. This can often result in tracking problems that are difficult to pinpoint and for which no amount of steering idler adjustment can compensate.

There can also be significant environmental and health and safety consequences, especially when the belt is being used to carry materials such as cement, coal or other fuels, because fine particles of dust penetrate the cracks. This dust is then discharged on the return run of the belt.

Magnifying other causes of damage

Apart from the damage caused in their own right, the cracking of the rubber covers by ozone and UV exposure also play a major role in magnifying other causes of damage. As the rubber covers become more brittle and lose strength they also lose the ability to resist abrasive wear. Oil-resistant belts also suffer because

Right: Checking for cracks every two hours.

the cracked surface allows the oil to penetrate much more quickly and deeply, leading to increased swelling and belt distortion. In heat-resistant belts the cracks allow heat to penetrate the carcass more easily. An increase of only 10°C in the core temperature of the belt carcass can reduce the life of the belt by as much as 50%.

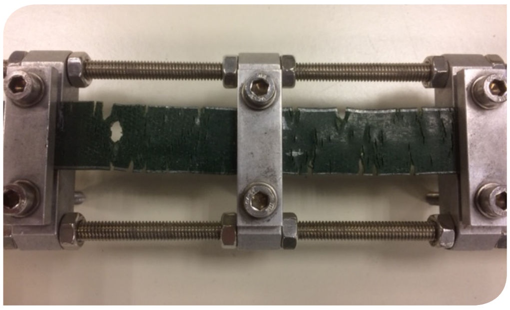
Excluding accidental mechanical damage, unless they are being used to transport extremely aggressive materials, modern-day conveyor belts should be expected to last for many years. However, conveyor operators continue to replace belts months and years before they should have to, completely unaware that the need to replace has almost certainly been accelerated by the effects of ozone and UV light.

New technology

Several years ago, Dunlop Conveyor Belting was amongst the very first in the world to make use of new technology that enabled the effects of ozone to be tested and measured. It invested in the very latest ozone testing equipment for its research and development laboratory. Mandatory testing to EN/ISO 1431 international standards was introduced for all Dunlop belt products and comparison tests also applied to samples of belts made by other manufacturers.

As a direct result, special anti-oxidant additives that act as highly efficient anti-ozonants were introduced into all Dunlop rubber compound recipes to provide protection against the damaging effects of ozone and UV light, thereby further extending the working life of its belts.

Right: Splice joints are prone to stress concentrations.



Right: Some rubber literally disintegrates.

EN/ISO 1431 testing

To scientifically measure resistance to ozone in accordance with the EN/ISO 1431 test method, samples are placed under tension (20% elongation) inside an ozone testing cabinet and exposed to highly concentrated levels of ozone for a period up to 96hr. Every sample is then closely examined for evidence of cracking at two hour intervals and the results carefully measured and recorded.

Due to the sheer size of industrial conveyor belts, it is common practice for manufacturers and distributors to store rolls of belting in open-air storage yards. Belts can often be held in stock for long periods, sometimes for several years, before they are eventually despatched to their final destination and ultimately put to use. During that time they are vulnerable to the effects of ozone and UV radiation. A number of conveyor belt users have reported that surface cracking was apparent at the time of delivery.

No hiding place

The importance of having conveyor belts that are resistant to ozone and UV light can no longer be ignored by those that use them. Unless conveyor operators start insisting on ozone and UV resistance then belt manufacturers and suppliers will continue to ignore the issue. You will hardly ever find a belt manufacturer or supplier that even mentions ozone or UV. This is because the anti-ozonants required to create the necessary resistance cost money upfront. They do, of course, appreciably extend the operating life of the belt supplied.

It may sound cynical but the reality is that it is not really in the best interests of belt manufacturers (or traders and service companies for that matter) for conveyor belts to run and run and run, particularly if they are trying to compete on price, which is a common approach. This is especially so when you consider that a huge proportion of belting is directly or indirectly imported from Asia. Dunlop rarely tests a competitor's belt (and never an Asian import belt as far as the author knows) that has survived the EN/ISO 1431 test specific conditions without cracking. In many cases the rubber literally disintegrates.

For all buyers of rubber conveyor belts there must now be two absolute pre-requisites when choosing any type of belt. Firstly, regardless of type, the rubber covers must always have good resistance to abrasive wear and, just as importantly, they must be fully resistant to the effects of ozone and UV light. Without these all-important properties the belt will not provide genuine value for money because it will need to be replaced far sooner than necessary.

Dunlop Conveyor Belting's advice is to always insist on certification provided by the actual manufacturer that confirms that the belt ordered is fully resistant to ozone and UV in accordance with the EN/ISO 1431 test method.