CRACKING UP

LES WILLIAMS, DUNLOP CONVEYOR BELTING, THE NETHERLANDS, DISCUSSES THE EFFECTS OF OZONE ON RUBBER CONVEYOR BELTS.

Conveyor belts are invariably a very significant purchase for any company, not only in terms of the actual capital expenditure but also the considerable impact of 'invisible costs' caused by belts that underperform, require high levels of maintenance or simply need replacing prematurely. As a consequence, users of conveyor belts (and hopefully their suppliers) usually go to great lengths to make sure that full and proper consideration is given to a wide range of technical factors, such as pulley diameters, tensile strength, troughing angles and much more.

Depending on the type of materials being conveyed, resistance to impact, ripping and/or tearing comes into the equation. Then there is the type of cover quality to consider, such as resistance to abrasion, heat or oil, or maybe a combination of factors, such as resistance to the effects of both fire and oil.

Of course, these are all well recognised as being everyday considerations for those responsible for selecting the most suitable and cost-effective conveyor belts to meet their company's needs. What is perhaps less well recognised (and publicised) within the world of industrial conveyor belts are the extremely harmful long-term effects of ozone on rubber conveyor belts.

From protector to aggressor

Ozone occurs naturally in the upper atmosphere, where it is formed continuously by the action of solar

Dunlop's ozone testing cabinet.

Samples under test.

Competitor's belt sample showing surface cracking

ultraviolet radiation on molecular oxygen. At high altitude, ozone acts as a protective shield by absorbing harmful ultraviolet rays. Wind currents carry ozone to the atmosphere at the Earth's surface.

Ozone also occurs in cities and industrialised areas, when it is formed by the photolysis of nitrogen dioxide from automobile exhaust and industrial discharges. The actual level of ozone at ground level, and therefore the level of exposure, can vary depending on geographical and climatic conditions, such as higher altitudes and coastal areas. Due to the variability of weather, airflow patterns, seasonal changes, and motor vehicle and industrial emissions, ozone concentrations can differ greatly from one location to another. While the general concentration of ozone in the air is from 0 to 6 parts/100 million of air, major cities, for example, can have ozone levels ranging from 5 to 25 parts/100 million.

Ultraviolet radiation causes chemical reactions to take place within rubber. The rapid decline in the ozone layer in the upper atmosphere over the past several decades is allowing an increasing level of UV radiation to reach the Earth's surface.

At low altitude, ozone itself is a pollutant. Scientific research has shown that exposure to ozone increases the acidity of carbon black surfaces and causes reactions to take place within the molecular structure of the rubber. This can have several consequences, such as a surface cracking and a decrease in the tensile strength of the rubber. It is inevitable that belts operating on the surface rather than below ground are more vulnerable to the effects of prolonged exposure to ozone.

Belts that do not operate under shelter are especially prone to surface cracking, which can have serious consequences in terms of the performance of the belt and its working life. There can also be significant environmental and health and safety consequences, especially in the coal industry because fine particles of coal dust penetrate the surface cracks, which are then discharged (shaken out) on the return (underside) run of the belt.

Hidden effects

At first glance, fine cracks in the surface rubber may not seem to be a major problem, but over a period of time the rubber becomes increasingly brittle. Transversal cracks deepen under the repeated stress of passing over the pulleys and drums and, if the conveyor has a relatively short transition distance, longitudinal cracks can also begin to appear. Again, surface cracking may not initially seem to be a cause of concern but there are often hidden long-term effects.

One of those hidden effects is that moisture seeps into the cracks and is able to penetrate through the belt covers 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 which no amount of steering idler adjustment can compensate for.

Other negative effects include scrapers catching on the cracks and tearing off parts of the cover and that re-splicing can become more and more difficult as the adhesion properties of the rubber diminish.

Because coal is relatively soft and not particularly abrasive, belts carrying coal should (excluding accidental mechanical damage) be expected to last for many years. However, it is becoming increasingly common to see belts being replaced prematurely because of surface

Environment issue? Coal dust can be shaken out from the underside of the belt.

cracking, even though the covers are not completely worn.

Other causes and effects

Another source of ozone that is relevant to the coal industry is the ozone produced by the action of a high electrical potential difference in the presence of an alternating current. This occurs in most electrical equipment, for example, electrical generators. This can apply to any machine that has an electric motor that comes in contact with the molecular oxygen in the air. If there is a high enough concentration of ozone in the immediate area of use, then significant oxidation can occur.

Other factors that contribute to the effects of ozone on rubber deterioration include sources of heat and light. Excessive exposure to heat can accelerate the oxidation process and cause cracks to appear sooner than would occur if exposed to ozone alone. Ultraviolet light from sunlight and fluorescent lighting can also accelerate deterioration because they produce photochemical reactions in rubber that can promote the oxidation of the surface of the rubber, resulting in a loss in mechanical strength.

New technology

Several years ago, Dunlop Conveyor Belting was amongst the very first to make use of new technology that enabled the effects of ozone to be tested and measured. 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, thereby further extending the operational life.

Because of the growing importance of ozone resistance, Dunlop has invested in the latest, state-of-the-art testing equipment in their R&D laboratory. Mandatory testing to EN/ISO 1431 international standards using an ozone testing cabinet has been introduced for all Dunlop belting products and comparison tests also applied to samples of belts made by other manufacturers.

EN/ISO 1431 testing

To scientifically measure resistance to ozone in accordance with EN/ISO 1431, samples are placed under tension (20% elongation) inside the ozone testing cabinet and exposed to highly concentrated levels of ozone for a period up to 96 hours. Every sample is closely examined for evidence of cracking at two hourly intervals and the results carefully measured and recorded. Dunlop's technicians say that as a general rule, based on their experience, failure to exceed more than 8 hours under test without surface cracking will most likely correlate to less than 2 years in normal working conditions before the belt starts to deteriorate.

Users of conveyor belts may experience even shorter time spans before cracks in the belt surface start to appear. Because of the sheer size of industrial conveyor belts, it is common practice amongst 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 even arrive at their final destination and put to use. This, of course, means that they are exposed 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.

To provide fair and accurate comparison data when testing samples of belts produced by competitors, the Dunlop technicians tested a number of samples from each manufacturer. These were often produced by different factories owned by the same company. In several cases the technicians found quite startling inconsistencies in the results, with some demonstrating high resistance to ozone exposure, while other samples from the same manufacturer showed minimal resistance.

Dunlop's director of production and product development, Dr Michiel Eijpe, believes that EN/ISO 1431 ozone resistance testing has proved to be a wise investment. "Carrying out these tests has enabled us to ensure that all Dunlop (belt) covers reach the highest possible level of resistance to ozone. It is a very important quality advantage." WC

Note

If end users require more information on ozone resistance of conveyor belting then they are welcome to contact the company's Application Engineering Department.