HANDLING THE HEAT

Dr. Michiel Eijpe, Dunlop Conveyor Belting, details how heat-resistant rubber is created and explains why not all heat-resistant conveyor belts are equal.

Nothing destroys a rubber conveyor belt faster than heat. It is a common misconception that all heat-resistant conveyor belts of a stated specification should provide a similar performance and operational lifetime. In reality, alarming differences are commonplace. However, before looking at the reasons for such differences, it is perhaps a good idea to first clarify the different specifications

applicable to heat-resistant conveyor belts and the associated terminology.

The temperature limits that a belt can withstand are viewed in two ways – the maximum continuous temperature of the conveyed material and the maximum temporary peak temperature. Heat-resistant grades are historically identified as grade 'T'. The international ISO 4195 specifies the requirements for heat-resistant belt covers, which spans classes 1, 2, and 3. The two identifications are commonly combined into classes T1, T2, and T3 respectively, although some use T100, T150, and T200 instead. The most important thing to remember is that there are only two main classifications of heat resistance recognised in the market. These are T150, which relates to a maximum continuous temperature of 150˚C and T200, which is for more extreme heat conditions up to 200˚C.

Continuous and peak temperatures

The difference between continuous temperatures and peak temperatures is a critical issue and is the most common cause of warranty disputes. For example, although a belt classified as T150 should consistently withstand continuous material temperatures up to a maximum of 150˚C over long periods, it can only cope with peak temperatures in excess of that limit for a very short period of time (literally minutes). The same principle applies to the T200 classification for peak temperatures higher than 200˚C. Any period longer than just a few minutes will almost certainly cause irreparable damage to the belt.

Nothing destroys a rubber conveyor belt faster than heat.

Any period longer than a few minutes at excess temperatures can cause irreparable damage.

To provide a working example of what this means, at Dunlop the ISO 4195 class 2, or T150, belt is Betahete, which is designed for materials at continuous temperatures up to 160˚C and peak temperatures as high as 180˚C. For ISO 4195 class 3, or T200, there is Dunlop Deltahete, which is engineered to withstand maximum continuous material temperatures as high as 200˚C and extreme peak temperatures as high as 400˚C.

ISO 4195 testing

The T150 and T200 classifications should not be confused with the requirements used within the ISO 4195 test methods that measure the heat-resistant properties of rubber conveyor belts. The tests involve placing rubber samples in high temperature ovens for a period of seven days. This testing procedure is known as 'accelerated ageing'. At the end of the seven days the reduction in mechanical properties such as tensile strength, elongation and hardness are then measured. There are three 'classes' of ageing within ISO 4195, each with a respective 'ageing temperature' – class 1 (100˚C), class 2 (125˚C), and class 3 (150°C). In order to maximise temperature-resistant qualities for class 3, Dunlop also carries out testing at 175°C.

To be able to best understand the reasons for the significant differences in the working life of one heat-resistant conveyor belt and another it is important to understand the damaging processes that occur when they are exposed to heat. Although rubber is obviously not a lifeform, the one thing that it has in common with organic life is that it ages. As it ages, it deteriorates. What heat does is accelerate the ageing process. As far as rubber conveyor belts are concerned, there are two forms of ageing – thermal and oxidative.

Thermal ageing

High temperature materials and working environments rapidly accelerate the ageing process of the outer rubber covers, causing them to harden and crack. High temperatures also have an extremely destructive effect on the inner carcass of the belt by gradually destroying the adhesion between the rubber covers on the top and bottom of the carcass and between the inner plies contained within it. The result, referred to as 'de-lamination', is that the layers of the belt become detached from one another.

As the rubber becomes harder and less elastic, the tensile strength and elongation (stretch) can be reduced by as much as 80%. This effectively destroys the operational strength and flexibility of the belt and seriously weakens the splice joints. At the same time, surface cover wear is accelerated because the rubber's resistance to abrasive wear decreases by as much as 40% or more. As the covers become thinner, their ability to protect the inner carcass from temperature buildup diminishes, creating a vicious cycle that further accelerates both the de-lamination and ageing processes.

Oxidative ageing

Apart from thermal ageing caused by exposure to heat, the most common cause of rubber deterioration and degradation is oxidative ageing. It is a little known fact that oxidative ageing is primarily caused by exposure to ultraviolet (UV) light (sunlight and fluorescent light) and other reactive gases, especially ground level ozone. All three of these factors cause rubber to become brittle and crack, while the dynamic stress caused by the belt travelling around pulleys and drums under tension greatly accelerates the formation of these cracks.

How heat-resistant rubber is created

The quality of the rubber always has the biggest bearing on the performance and cost-effectiveness of any conveyor belt but in the case of heat-resistant belts, it has a much higher significance. The vast majority of rubber used to make heat-resistant conveyor belts is synthetic. This is because it is far more adaptable than natural rubber and can be more precisely engineered to cope with the many combinations of different physical demands placed on conveyor belts.

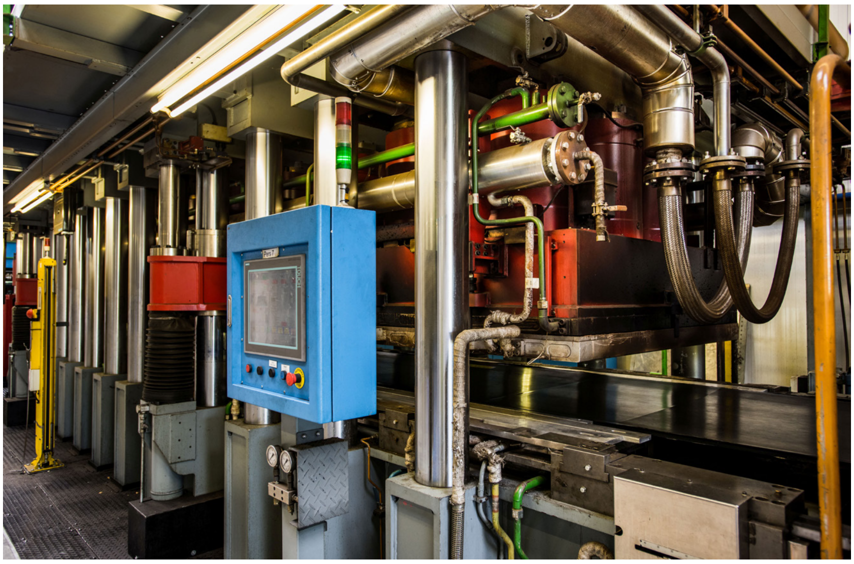
Delamination – the layers of the belt detach themselves.

In addition to resisting the effects of thermal ageing, the rubber must also be fully resistant to the oxidative ageing caused by ozone and ultraviolet light mentioned previously. This resistance can only be achieved by the addition of UV stabilisers, anti-ozonates, and anti-oxidants as part of the compound recipe during the mixing process. Each different rubber compound consists of a complex 'cocktail' of different chemical components, polymers, and other essential substances. In the case of heat resistance, it is relatively easy to create a rubber that will resist even the most extreme temperatures. However, the most difficult and costly part is to design a rubber compound that can resist those temperatures and delay the ageing process for the longest possible time.

A combination of qualities

The list of required qualities does not stop there because the rubber also has to act as a heat shield for the belt carcass as well as having good wear resistance, tensile strength, and durability. Protecting the carcass is vital because an increase as small as 10˚C in core temperature can reduce the life of the belt by as much as 50%. This is because for every 10˚C increase in temperature, the rate of rubber oxidation increases by a factor of eight.

If the core temperature of the carcass becomes too high then the bond between the covers and fabric layers will separate (delaminate) and the belt will quite literally begin to fall apart. With all of these demands in mind, it is no wonder that developing a rubber that can reliably and consistently meet the challenge is regarded as one of the toughest challenges in the rubber industry.



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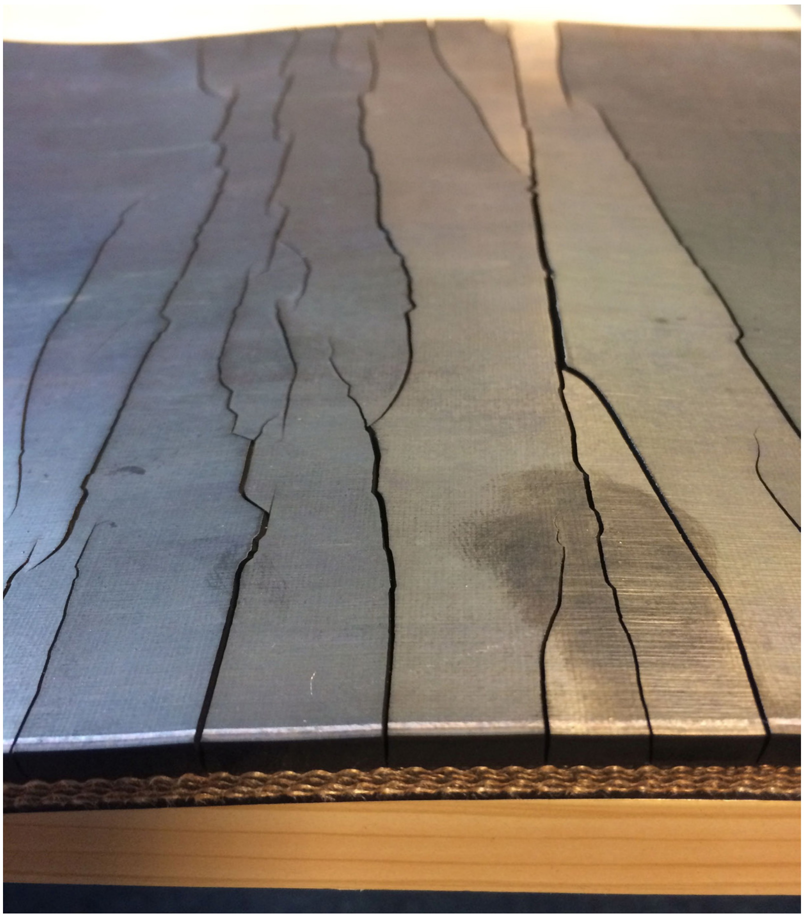
Vulcanisation – a conflict of interest?

The rubber compound then needs to be vulcanised. For the uninitiated, vulcanisation is the chemical process in which the rubber mixture including, for example, sulfur, accelerator, and activator, is typically heated at 140 – 160˚C. The scientific process involves the formation of cross-links between long rubber molecular chains in order to achieve improved elasticity, resilience, tensile strength, viscosity, and hardness. It is therefore a crucial part of the production process. For T150 classification belts, the necessary physical properties can be achieved using a styrene butadiene rubber (SBR) and a process of chemical alteration of the various polymers together with the use of other components and accelerants.

For the higher temperature range of the T200 classification however, it is necessary to replace the SBR with more complex and expensive polymers such as ethylene propylene rubber (EPM) and ethylene propylene diene monomer rubber (EPDM), which have a superior resistance to heat. A different, more complex vulcanising mechanism involving hydrogen peroxide is also required.

Ironically, vulcanisation poses something of a conflict of interest for the manufacturer. Because it is a heat process, it takes appreciably longer to vulcanise heat-resistant rubber compared to non-heat-resistant rubber. In basic terms, the more heat-resistant the rubber then the longer it needs to spend on the production line. Time, of course, is money, which is why heat-resistant belts are appreciably more expensive than abrasion-resistant belts. As mentioned earlier, it is relatively easy to create a rubber that will resist high temperatures for a limited period but much more difficult and expensive to engineer a rubber compound that can resist high temperatures for prolonged periods.



Some crack earlier than others – not all heat-resistant belts perform the same.

Opposing ends of the market

The alternatives open to the manufacturer depend upon their approach to the market in terms of price range. In today's conveyor belt market, there are two distinct 'camps'. By far the biggest is the 'pile it high, sell it cheap', low price, low grade end of the market. This is totally dominated by Southeast Asian manufacturers. The other end of the scale is the premium quality sector. The rubber used for conveyor belts usually constitutes up to 70% of the material mass and is the single biggest element of cost. Consequently, for manufacturers who want to compete for business based on price rather than operational longevity, rubber is their biggest opportunity to gain a competitive edge. An example of this is the omission of the UV stabilisers, anti-ozonates, and anti-oxidants necessary to create a resistance to ozone and ultra violet light during the mixing process.

In the case of heat-resistant belts, there are the twin benefits of making the rubber as cheaply as possible and being able to vulcanise faster. Alternatively, a manufacturer can create a premium quality compound that effectively delays both the thermal and oxidative ageing process for much longer periods but which takes much longer to vulcanise. In a nutshell, how effectively all this is achieved dictates the operational lifetime and consequently the cost-effectiveness of the belt. It is also the primary reason why there are such huge variances in both price and performance between heat-resistant belts of supposedly the same specifications.

There is a reason for the price difference

Operators should never accept that their so-called heat-resistant belts will only ever last a few weeks or months. As explained, there are very real reasons why there are such enormous differences in the performance and longevity of one heat-resistant belt compared to another and the best indicator of that difference is the price! If plants select belts based on lowest whole life cost rather than simply the lowest selling price then they will avoid a lot of problems and save a considerable amount of money. ■

About the author

Dr. Michiel Eijpe is technical director of Dunlop Conveyor Belting in the Netherlands. A former university lecturer, he has worked in the conveyor belt industry for over 25 years. He has a PhD in fibre-reinforced polymer composites and is a leading light in the development of high-performance conveyor belting and conveyor belt manufacturing technology.