WITHSTANDING THE HEAT

Dr. Michiel Eijpe, Fenner Dunlop, explains why huge disparities exist in terms of performance and working life expectancy between different manufacturers of heat resistant conveyor belts.

Although all heat-resistant conveyor belts of a stated specification should, in theory, provide a similar performance and operational lifetime, in truth, alarming differences are commonplace. To understand the reasons for such differences it is necessary

to understand the standards and classifications applicable to heat resistant belts.

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. International ISO 4195 standards specify the requirements for heat resistant belt covers within three classes. These identifications are commonly referred to as classes T1, T2, and T3, 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 designed for more extreme continuous heat exposure of up to 200˚C.

The T150 and T200 classifications should not be confused with the requirements used within the ISO 4195 heat resistance test methods, which involve placing rubber samples in high temperature ovens for a period of 7 days. This testing procedure is known as 'accelerated ageing'. 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 resistance qualities for class 3, Dunlop also tests at 175˚C.

Anything longer than a few minutes exposure to excess temperatures can cause irreparable damage.

Delamination – the layers of the belt detach themselves.

Every rubber compound is a complex 'cocktail' of different chemical components and polymers.

Continuous and peak temperatures

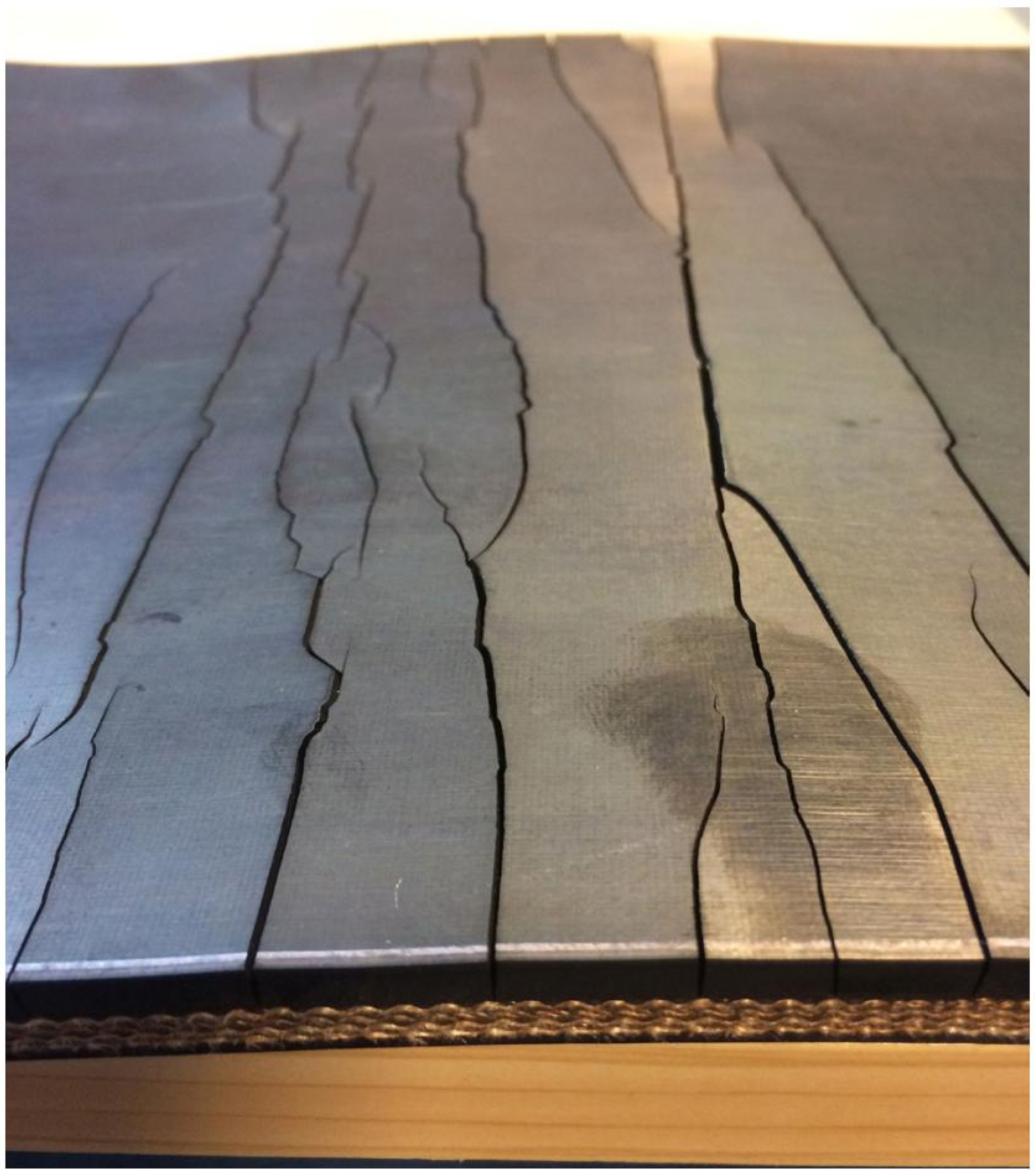
The difference between continuous temperatures and peak temperatures is critical and the most common cause of warranty disputes. For example, although a belt classified as T150 should consistently withstand continuous material temperatures up to a maximum of 150˚C over long periods, it can only cope 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 exposure longer than a few minutes will almost certainly cause irreparable damage to the belt.

For example, at Fenner Dunlop the ISO 4195 class 2 or T150 belt (Betahete), is designed for materials at continuous temperatures up to 160˚C and peak temperatures as high as 180˚C. For class 3 or T200 Fenner Dunlop have Deltahete, which is engineered to withstand maximum continuous material temperatures up to 200˚C and extreme peak temperatures as high as 400˚C.

To best understand the reasons for the significant differences in working life, it is important to understand how damage occurs when rubber is exposed to high temperatures. Although obviously not a lifeform, the one thing that rubber has in

An increase as small as 10˚C in core temperature can cause a belt to fall apart.

Vulcanisation is a crucial part of the production process.



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

common with organic life is that it ages, and as it ages, it deteriorates. Heat accelerates the ageing process, of which there are two forms – thermal and oxidative.

Thermal ageing

High temperature materials and hot working environments rapidly accelerate the ageing process of the outer rubber covers, causing them to harden and crack. They 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 literally become detached from one another.

As rubber becomes harder and less elastic, 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 build-up diminishes, creating a vicious cycle that further accelerates both the de-lamination and ageing processes.

Oxidative ageing

Apart from thermal ageing, the most common cause of rubber deterioration and degradation is oxidative ageing, which is primarily caused by exposure to ultraviolet light (sunlight and fluorescent light) and other reactive gases, especially ground level ozone. All three factors cause rubber to become brittle and crack. The dynamic stress caused by the belt travelling around pulleys and drums under tension greatly accelerates the formation of the cracks. One of the many consequences of this process is that heat is more able to reach the inner carcass.

Heat-resistant rubber

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 an even higher significance. The vast majority of rubber used to make conveyor belts is synthetic because it can be more precisely engineered to cope with the many combinations of different physical demands placed on conveyor belts.

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, which can only be achieved by the inclusion of UV stabilisers, anti-ozonates, and antioxidants 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. It is relatively easy to create a rubber that will resist even the most extreme heat but the most difficult (and costly) part is designing a rubber compound that can resist the immediate effect of high temperatures while delaying the ageing process for the longest possible time.

A combination of qualities

The rubber must also 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 of only 10˚C in the core temperature causes the rate of rubber oxidation to increase by a factor of eight. If the core temperature of the carcass becomes too high, the bond between the covers and fabric layers separates (delaminates) and the belt will quite literally fall apart. With these demands in mind, it is hardly surprising that formulating a rubber that can reliably and consistently meet the demand is regarded as one of the toughest challenges in rubber technology.

Vulcanisation – a conflict of interest?

The rubber compound then needs to be vulcanised, which is the chemical process where the rubber mixture is typically heated at 140 – 160˚C to achieve elasticity, resilience, tensile strength, viscosity, and hardness. This 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).

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

The dilemma facing the manufacturer is that vulcanisation is a heat process, so it takes appreciably longer to vulcanise high-quality heat-resistant rubber compared to a mediocre level of heat resistance. Basically, the more the rubber is resistant to heat, the more time it takes. This is why heat-resistant belts are appreciably more expensive, because it is much more difficult and much more costly to engineer a rubber compound that can resist high temperatures for prolonged periods.

Opposing ends of the market

There are two conflicting market approaches. By far the biggest is the low-price, low-grade end approach used by used by south and east Asian manufacturers to compete against the hi-performance, greater longevity, premium quality sector. Rubber usually constitutes up to 70% of the material mass and some 50% of the production cost of a conveyor belt, so it is the biggest opportunity to gain a competitive edge for those wanting to compete for market share by weaponising price.

The EPM and EPDM polymers needed to withstand higher temperatures and prevent ageing cost appreciably more than regular polymers, and so minimising their use creates an important saving. The same applies to the omission of vital, life-prolonging UV stabilisers, anti-ozonates, and antioxidants that protect against ozone and ultraviolet light. Surveys have revealed that more than 80% of belts imported from South and East Asia do not contain these essential ingredients. A more sinister but nonetheless valid aspect of limited or non-use of protective agents is that prolonging the working life of belts is not good for business; together, these factors explain the widespread absence of protection.

Finally, another benefit of producing cheaper rubber is the ability to vulcanise it much more quickly. How effectively this is achieved dictates the operational lifetime and, consequently, the whole-life cost of the belt. It is also the primary reason why there are such large variations in both price and performance among heat-resistant belts of supposedly the same specification.

So-called heat-resistant belts should not be expected to last only a few weeks or months. There are very real reasons for such enormous differences in the performance and longevity, and the best indicator of that difference is invariably the price.

Selecting heat-resistant belts based on whole life cost rather than lowest buying price will avoid a lot of splice problems, stoppages, and frequent belt replacements, and therefore boost output while saving a considerable amount of money. ■

About the author

Dr. Michiel Eijpe is Innovation & Sustainability Director of Fenner Dunlop Conveyor Belting EMEA in the Netherlands. A former university lecturer, he has worked in the conveyor belt industry for over 27 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.