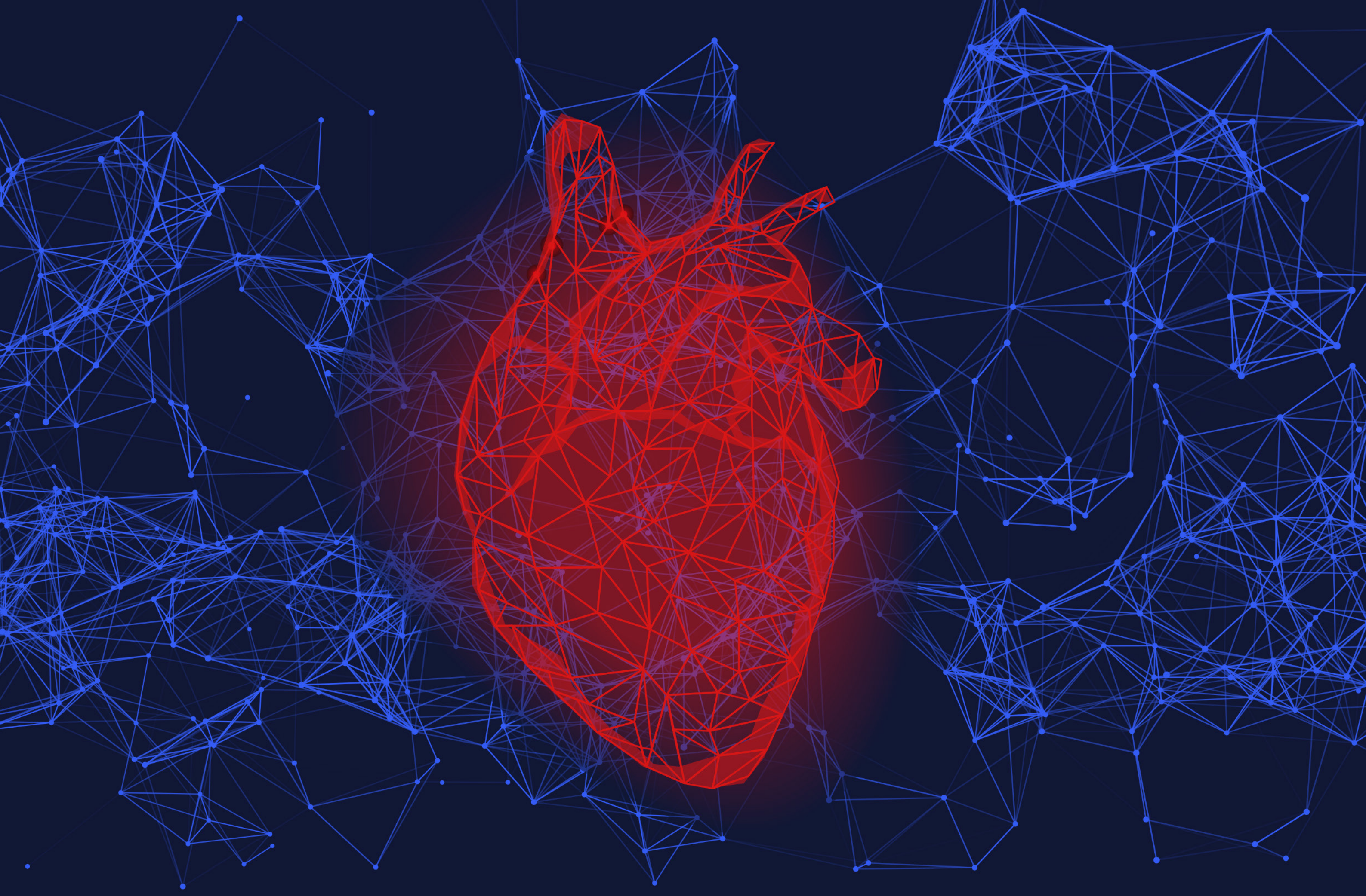
THE HEART OF THE MATTER



Leslie David, Conveyor Belt Specialist, highlights how deficiencies in the carcass of a conveyor belt significantly reduce both performance and longevity.

Rubber belts with a 'multi-ply' synthetic textile reinforced inner carcass are the most commonly used type of conveyor belt. The inner carcass serves as the belt's core structural element and provides the inherent characteristics of every conveyor belt, such as its tensile strength and elongation (elasticity or 'stretch' under tension). Its primary function is to transmit the tension required to lift and move the loaded belt, while also absorbing the impact energy generated as material is loaded onto the belt.

The rubber covers, rather than the carcass, are widely considered to have the biggest bearing on operational performance and longevity. This is perhaps because the thick outer covering of rubber makes the carcass invisible to the eye. Whatever the reason, the fact remains that the carcass is the heart of every conveyor belt. Its importance should never be underestimated because deficiencies can be extremely costly.

Figure 1. Out of sight, out of mind. Looks fine on the outside, but what is happening inside?

Figure 2. Not what they seem – some belts are supplied totally EE fabric plies in a carcass declared as being an EP carcass.

Figure 3. There can be enormous differences in the strength and quality of the fabric, and a corresponding difference in their cost.

Fabric quality

Almost without exception, rubber multi-ply belts use synthetic fabrics. Currently, the most commonly used type is a combination of polyester and nylon (polyamide), referred as 'EP'. Even in belts that have low quality (low cost) fabrics, it is unusual to find a fabric that has inadequate tensile strength. However, although the amount of material used in the longitudinal strands of the fabric may be sufficient to achieve the required tensile strength, to reduce cost, the use of the more costly nylon transversal weft material is kept to a minimum. As a consequence, rip and tear resistance are reduced and elongation (stretch) is low, which can cause problems with transition distances and a general inability to accommodate the contours of the conveyor and its drums and pulleys. Ultimately, this can lead to the premature failure of the belt.

A common deception

Unfortunately, due to price competition, it is becoming increasingly common for some manufacturers, traders, and importers to supply belts that have totally polyester (EE) fabric plies in a carcass that is declared to be a polyester/nylon mix (EP) construction. The reason for this deception is that EE fabric costs some 30% less than EP fabric. This is significant because, after rubber, the fabric is the highest cost component, so using cheaper polyester fabric is a big help towards achieving the perception of a lower 'like for like' price.

The basis of using a mix of polyester and nylon fabric is that it has the best balance of mechanical properties, including allowing a conveyor belt to run straight, to trough, to flex round pulleys and drums, stretch, provide transversal rigidity, longitudinal strength, and much more besides. Unless the weave pattern has been very specifically designed and manufactured, the use of totally EE fabric compromises a number of essential mechanical properties. The biggest danger is that, in a conventional weave, a polyester weft can cause low transverse elasticity, which reduces troughability, impact resistance, and also causes tracking issues.

It is important to note that the use of EE fabrics does play an important role in certain applications (e.g. sawmill belts) and special constructions, such as the unique fabrics used by Fenner Dunlop in Europe and North America to produce its high-performance single and dual-ply X Series range. However, under no circumstances should a belt be supplied that contains EE fabric that has been specified as being an EP construction.

There can be enormous differences in the strength and quality of the actual fabric, and a corresponding difference in their cost. Yet again, this is almost entirely influenced by whether the belt manufacturer is at the 'quality end' of the market or the 'cut-throat' end.

Although they may be the same specification on paper, the strength under load, both longitudinally and transversely, can be inconsistent and prone to steering and handling problems.

There are also different grades of fabric that can be used. For example, nylon 6 and nylon 66 are most commonly used for conveyor belt fabrics. The primary difference between them lies in their chemical structure, with nylon 66 being generally stronger, stiffer, and more heat resistant, whereas nylon 6 is slightly softer and more flexible, making it better for applications requiring a higher level of impact resistance and better elastic recovery.

The differences can be considerable. For example, nylon 66 fibres are 33% more resistant to abrasion compared to nylon 6, withstanding up to 60 000 cycles compared to 40 000, and are often used in high-performance industrial components. Both grades have their place, depending on the belt specification and intended use. The most important point here is that those manufacturers searching for economy will use the lowest cost option regardless of its suitability.

Rip, tear, and impact damage

Being able to withstand the forces that cause rip, tear, and impact damage is often more important than any other physical attribute. To try and prolong operational lifetime and minimise repairs, many conveyor belt users fit belts with extra-thick covers, but this is invariably a mistake because it can cause a number of other problems. The greatest influence on the strength and other essential physical properties of a conveyor belt is the design and quality of the ply material used to create the carcass. As a result, the most practical and economical solution to rip, tear, and impact problems is to fit a belt that has been specifically engineered for the purpose, especially the strength and weave design of the fabric.

The unique range of special fabrics developed and manufactured by Fenner Dunlop provide an example of 'specific task engineering'. What they all have in common is weave patterns that consist of longitudinal strands lengthwise, and heavy strands running crosswise, held in position by a strong yarn. In Fenner Dunlop's UsFlex fabrics, the strands are completely straight in both directions and not interlocked as in conventional fabric. This allows the weft to float free from the warp, creating a shock absorber effect by dissipating impact energy over a larger area, allowing the belt to withstand the kind of punishment that would destroy a normal multi-ply belt. Arguably even more important is the ability to resist rip and tear damage. When penetrated, and being pulled through a trapped object such as a large, sharp rock, the unique weave design allows the strands to gather in a bundle that can eventually become strong enough to stop the belt or even expel the object causing the damage. Strange as it may seem, synthetic plies are usually more effective than steel when it comes to minimising the length of a rip.

Figure 4. Fenner Dunlop engineer and manufacture their own 'special task' fabrics.

Figure 5. Weft strands bundle together to stop the belt or expel the penetrating object (Source: Fenner Dunlop).

Carcass failure caused by delamination

The term 'adhesion' relates to the adhesive bond between the inner ply layers to adjoining layers, and between the surfaces of the outer plies and the rubber covers. It is defined as the force required to separate adjoining plies and/or between the plies and the outer covers. The adhesion properties of a belt are fundamental to its durability, functionality, and structural integrity, and determine a belt's ability to trough and carry heavy loads without the risk of ply separation. Conveyor belts continually flex over pulleys and drums, which creates stress. It is therefore essential that the belt has adequate ply adhesion to withstand this stress without delaminating (where the various layers separate, and the belt literally falls apart).

Figure 6. Delamination – layers separate and the belt falls apart.

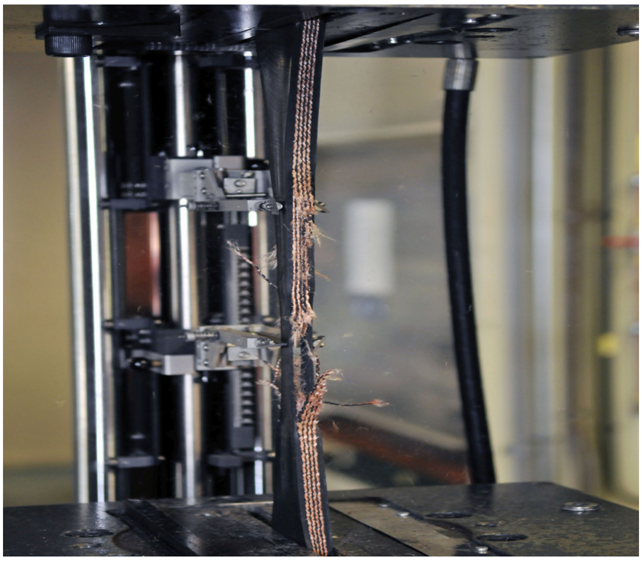


Figure 7. Elongation at break is the amount of elongation at the moment the belt breaks.

Adhesion also has an enormous impact on the reliability of splice joints because insufficient adhesion compromises the strength and longevity of the joint. Unsurprisingly, the root cause is the use of low-grade raw materials such as polymers, crucial fillers such as carbon black, vulcanising agents, plasticisers, resins, and curatives. Other causes include overheating or overcooking during the vulcanisation process, and the use of cheap bulking fillers such as chalk or clay.

Elongation – stretching the limits

Elongation is an often-misunderstood technical term applied to rubber conveyor belts. It is best defined as the change in length (stretch) of a belt when subjected to tensile stress of which there are three forms – elastic elongation, permanent elongation, and elongation at break. With each tensile stress below break load, the belt is subject to an elongation which, when the stress is relieved, partly recovers (elastic elongation) and partly remains (permanent elongation). The elongation at break is the amount of elongation at the moment the belt breaks. All three forms are effectively determined by the properties engineered into the belt during its manufacture. The primary influence on those properties is the quality, type, and weave design of the fabric plies, and secondary are the elongation characteristics of the rubber covers.

The elongation of a carcass is critical in determining how a belt will react when subjected to varying stress levels. These stresses change due to system influences such as tension, transitions, vertical and horizontal curves, turnovers, and crowned pulleys. Insufficient elongation is mostly an issue in areas where a multi-ply belt needs to stretch, such as troughing and bending around pulleys. It can cause localised tension build-up, which can have an especially negative effect on the splice joint. It can also lead to shear stresses that may, in turn, cause delamination (ply separation) issues. Conversely, too much elongation can result in insufficient tension, which can lead to premature wear and tear.

Conclusion

The quality of the carcass is of equal importance to the quality of the rubber covers. They are inter-dependant, and in both cases, when a low selling price is the driver rather than reliability and longevity, conveyor productivity suffers and running costs escalate. This is really the heart of the matter. GMR