Out of sight, out of mind

How deficiencies in the carcass of a conveyor belt significantly reduce both performance and longevity levels.

The core structural element of every conveyor belt is its inner carcass, which provides the inherent characteristics 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. However, there is more to it than that.

Perhaps because the thick outer covering of rubber makes the carcass invisible to the eye is why the rubber covers rather than the inner carcass is widely considered to have the biggest bearing on performance and longevity. Whatever the reason, the carcass is the backbone of every conveyor belt, and its importance should never be underestimated.

THE IMPORTANCE OF THE FABRIC.

Most rubber multi-ply and single-ply belts use synthetic fabrics, most commonly a combination of polyester and nylon (polyamide), referred to as 'EP'. The basis of using a mix of polyester and nylon fabric in multi-ply belts 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, the use of totally polyester 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. However, it is important to add that the use of all polyester (EE) fabrics does play an important role in certain applications such as sawmill belts for example.

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

Not what they claim - some belts are supplied totally polyester (EE) fabric plies in a carcass declared as being an EP (polyester/nylon) carcass

Unfortunately, an increasingly common deception employed by less scrupulous manufacturers, traders and importers is to supply belts that have totally polyester (EE) fabric plies in a carcass that is claimed to be an EP (polyester/nylon mix) construction. As a result, although the longitudinal strands of the fabric may be sufficient to achieve the required tensile strength, rip and tear resistance are reduced, and elongation (stretch) is lowered. This in turn can cause problems with transition distances and a general inability to accommodate the contours of the conveyor and its drums and pulleys, ultimately lead to premature failure.

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

The sole reason for this deception is that polyester costs some 30% less than nylon. This is significant because, after rubber, the fabric is the highest cost component. Consequently, using lower cost polyester fabric is a big help towards achieving the perception of a lower ‘like for like’ price.

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

CARCASS FAILURE CAUSED BY POOR ADHESION

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 determines a belt’s ability to trough and carry heavy loads without the risk of ply separation. The continual flexing over pulleys and drums creates stress so it is essential that the belt has adequate ply adhesion to withstand this without delaminating, which is where the various layers separate, and the belt literally falls apart.

Delamination - layers separate and the belt literally falls apart.

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, vulcanizing agents, plasticisers, resins and curatives. Other causes include overheating or overcooking during the vulcanization process and the use of cheap bulking fillers such as chalk or clay.

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 secondly, 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 round pulleys for example. 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 issues. Conversely, too much elongation can result in insufficient tension, which can lead to premature wear and tear.

SPECIALIST CARCASS FABRICS

Traditionally, single and dual ply carcass constructions are used for light applications. However, nowadays it is worth exploring special carcass constructions for medium to heavy duty applications, such as those used by Fenner Dunlop. Since the hugely ground-breaking introduction of their single and dual-ply UsFlex belt more than two decades ago, they have continued to develop the concept, known as the X Series range. Despite being thinner and lighter, they are successfully replacing traditional, thicker, heavier multi-layered belts because they are much more robust and resistant to damage and much less prone to the problems so often found in their multi-ply counterparts.

In theory, a higher number of inner plies should result in a stronger belt. However, 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. Fenner Dunlop have their own fabric weaving facility in the USA. It is here that they have developed a range of unique super-strength fabrics for single-ply belts (Ultra X and Nova X) and the longer established single and dual-ply UsFlex belts for more extreme working conditions. The carcasses possess a longitudinal rip resistance that is more than 500% greater than multi-ply belts of equivalent rating and up to 300% greater impact resistance compared to conventional belting.

The whole working principle of single and dual-ply belts firstly centres on using very high quality, super-strength fibres and

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

Inside Fenner Dunlop's fabric weaving facility in the USA.

Unique weave designs using high quality, super-strength individual fibres and yarns stops rips and tears in their tracks. (Image courtesy of Fenner Dunlop).

yarns followed by the design of the weave pattern, which is critical and unique to Fenner Dunlop. Ultra X features a specially woven "Crimped warp" carcass, combining crimped polyester warp yarns with strong binder and filler yarns, while the higher tensile strength Nova-X (available in North America and coming soon to Europe) uses an even stronger crimped warp fabric with binder yarns to lock the carcass. Both types provide very high rip, tear, and impact resistance under load. The heavier duty UsFlex employs a "Straight warp" fabric carcass, made of high-tenacity polyester fibres protected by polyamide weft lines.

What they all have in common is longitudinal strands lengthwise and heavy strands running crosswise that 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. This allows the belt to withstand the kind of punishment that would destroy a normal multi-ply belt. Arguably an even more significant advantage is the ability to resist rip and tear damage. When penetrated and being pulled through a trapped object such as a 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.

CONCLUSION

Whether single, dual or multi-ply, there is no doubt that 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 then reliability, longevity, productivity and running costs all suffer.

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ABOUT THE AUTHOR

After spending 23 years in logistics management, **Leslie David** has specialised in conveyor belting for over 19 years. During that time, he has become one of the most published authors on conveyor belt technology in the world.