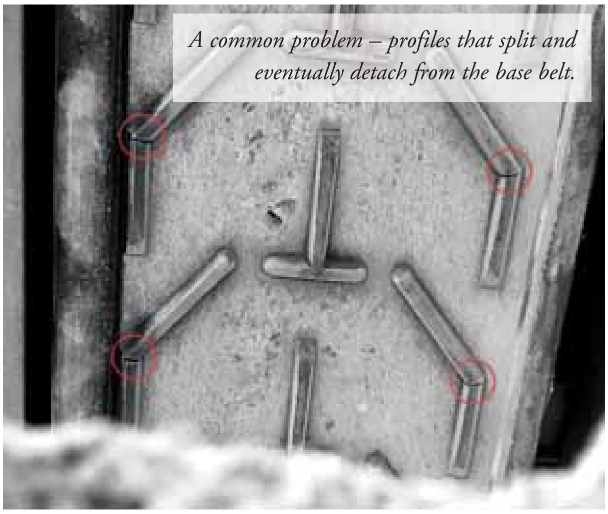
Raising the profile: a guide to rubber profiled and chevron conveyor belts

A great many ports and terminals use conveyors to transport materials up and down inclines and gradients. This is especially so in locations where space is at a premium. In some cases, because of the steepness of the incline, conveyor belts with various types of profiled surfaces are used in order to prevent the materials from slipping. Despite the important function they fulfil, very little is known about profiled belts and even less is known as to why some are so much more efficient and less troublesome than others. Here, *Les Williams of Netherlands-based Dunlop Conveyor Belting* explains how it all works and what to look out for when choosing belts for this kind of work.

Getting to grips

There are three principal types of profiled rubber conveyor belt. The most popular kind of profiled belts are those that have chevron-patterned profiles ranging from 15mm up to 32mm in height above the belt surface. The chevrons guide and control the flow of loose materials such as sand or small size aggregates for example. The second most common type are belts with low profiles, usually no more than 5mm.



A common problem – profiles that split and eventually detach from the base belt.

The third type of profiled belt are those that have a raised 'anti-slip' surface. Both low profile and anti-slip surface belts are most commonly used to transport packaged goods such as bags of cement or boxes along inclined conveyors.

One of the most common problems experienced by many operators affects high chevron belting because the chevron profiles can become partly detached or ripped off entirely.

With low profile and anti-slip surface belts the most common problem is that the profiles wear down too easily and/or simply lose their grip; often within an unacceptably short period of time. The origins of these problems (and more) are all to be found within the manufacturing processes and/or the rubber compounds that are used.

Conventionally produced chevron belting – The Achilles Heel

Because of its adaptability, most of the rubber used to make modern-day conveyor belting is synthetic. Because of the technical difficulties (and higher cost) involved in creating a synthetic rubber compound that will flow uniformly, the vast majority of chevron profile belts are effectively created using a two-stage vulcanization process. Firstly, a belt carcass consisting of layers of fabric reinforcing ply and covered by uncured rubber compound on the top and bottom surfaces is placed in the press. At the same time, a mould plate is filled with uncured rubber and the base structure is then placed on top of the filled mould.

Alternatively, the mould plate is extracted, filled with uncured rubber and then replaced back under the base structure. In both cases, the complete structure is then vulcanized to create the finished belt.

The key issue here is that the uncured rubber compound used to construct the base belt structure has to be different from the compound used to fill the moulds. This is because the rubber used in the moulds to create the chevron profiles has to be more malleable than the rubber used on the top and bottom covers in order for it to fill the mould cavity entirely. However, this creates the 'Achilles heel' for all chevron belts made in this way. The reason is that there will always be a contact point where two essentially different rubber compounds are joined, which then becomes a common point of weakness. The chevron profiles constantly stretch and flex under tension each time they run around a pulley or drum. Unless the bond between the base belt carcass and the chevron profile is absolutely flawless then


A 'single structure' chevron belt needs a highly specialized rubber.

sooner or later dynamic stress fractures will start to occur, causing the profile to split and eventually part company with the base belt.

The problem is magnified on conveyors with relatively small pulley diameters, especially mobile equipment. The smaller the pulley then the higher the dynamic stress. Failure will happen even sooner if one (or both) of the rubber compounds used are not fully resistant (as per ISO 1431 testing) to the effects of degradation (surface cracking) created by chemical reactions in the rubber caused by ground level ozone and ultra violet light.

Rapid wear

Having to use a rubber that is sufficiently malleable (pliable) so that it will fill the mould cavities and accept the dynamical strains of belt operation can create a second major weakness.

Research and experience has shown that the rubber used to make the chevrons in the two-step production process often has much poorer resistance to abrasive wear than normal. It is not unusual, especially among so-called 'economy' belts imported from Asia, that even chevrons as high as 25mm or 32mm can wear flat in a remarkably short time.

Make it once, make it strong

There is only one way to avoid the inherent weaknesses created by the conventional manufacturing methods that I have just described. Firstly it requires the use of a single rubber compound that has been specially engineered for both the base belt structure AND the chevrons. Secondly, it is essential that the belt is produced as a single, wholly homogenous structure. This can only be achieved using a one-step production process rather than the more conventional two-step process. In other words, make the belt once and make it very strong.

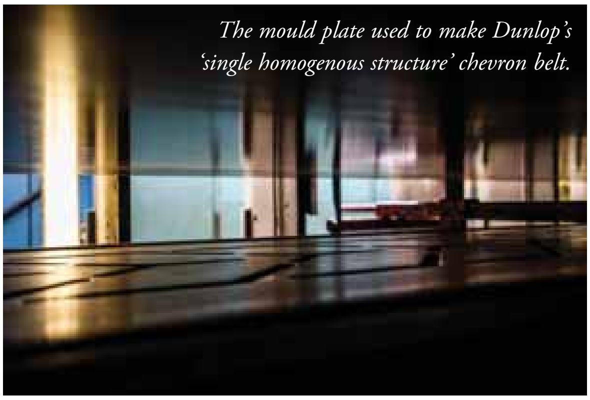
That is a surprisingly tall order because, first of all, it is extremely difficult (and more costly) to create such a versatile compound. This is largely due to the huge number of different chemicals, polymers and additives that are used to create the synthetic rubber. All of the various components have to be precisely balanced and mixed so that the final compound possesses all the necessary physical properties.

These properties include wear resistance, tensile strength and durability while at the same time also being sufficiently malleable to allow the rubber to flow smoothly and evenly into the moulds. The rubber then needs to be able to vulcanize virtually simultaneously within the mould AND the base belt structure. Not only that, the compound also needs to be fully resistant to the effects of ozone and ultra violet light and conform to European REACH regulations so that the end product is safe to handle.

'Single homogenous structure' chevron belting — how do they do it?

To create a single homogenous structure the base belt is placed in the vulcanising press between the base plate of the press and a chevron mould plate immediately below it. The base belt will already have a specific quantity of additional uncured rubber on the top cover surface. This extra rubber is in addition to the amount of rubber needed to achieve the minimum thickness of the top cover of the base belt once it has been vulcanized. The actual amount of 'extra' rubber needed depends on the depth of the chevron pattern (32mm for example). The compression of the upper and lower plates then forces the additional rubber to flow into the mould cavities. Vulcanization of both the base belt structure and the rubber-filled moulds then takes place simultaneously to form a single homogenous unit.

Bearing in mind the technical complexity and the higher costs involved, perhaps it is not surprising that apart from Dunlop Conveyor Belting, hardly any other manufacturer of note produces profiled chevron belt in this way. However, the significantly superior strength, reliability and much longer working life that is created by chevron belting being made in this way makes it totally worth the effort and, dare I say it, worth the investment.



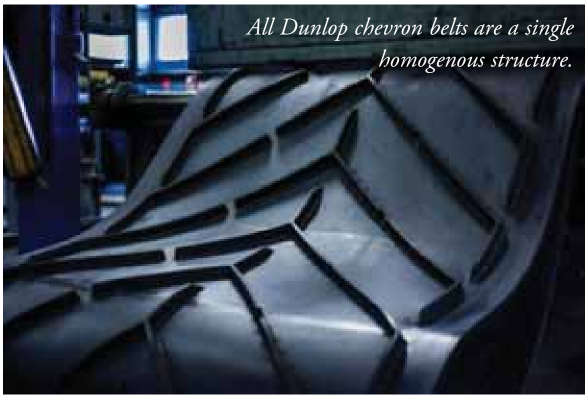
The mould plate used to make Dunlop's 'single homogenous structure' chevron belt.

How will I know?

Even when armed with this understanding of the huge difference in strength and overall durability between belts made using the conventional 'two-step' process and 'single homogenous structure' chevron belting, the dilemma then is how to establish which kind is being offered by the manufacturer/supplier who is providing the quotation. Unfortunately, the only way to find out is to ask the would-be supplier and then hope that the salesperson you are speaking to actually knows the difference. One place where you definitely do NOT have to ask that question is Dunlop in the Netherlands because all of its chevron belts are single homogenous structure!

Choosing the right profile height

'High' profile chevron belts are available in a variety of different heights, mostly 15mm, 25mm and 32mm. Some manufacturers only make the 25mm version whereas Dunlop produce a low chevron (16mm) version and a high-chevron (32mm) version. A combination of material properties and the system design of the actual application will determine what profile type or size (height) is required to achieve the desired capacity. A higher profile does not necessarily create a higher capacity and neither does it increase the workable incline angle. The use of a profiled belt may not even be possible on some existing system designs. The evaluation process behind it can be quite complicated. For example, system designs with counterweight take-up units cannot accept most types of profiled belts. Also, the smoothness in running behaviour of the belt is largely determined by the design of the profile pattern. This is something that becomes even more important when belt speeds increase or system designs get very tight.



All Dunlop chevron belts are a single homogenous structure.

Keeping a low profile

There are several belts on the market that have a very low profile pattern. These belts have profiles that are little more than 5mm high and sometimes even less. For example, Dunlop has two pattern designs — the Multiprof and the Fishbone. Multiprof is mostly used for the transportation of packaged goods such as boxes, bags and baggage as well as bulk materials including agricultural products, oily materials, woodchips and wet sand and can successfully be used on inclines as steep as 30° in some cases.

The Fishbone profile is most commonly used in the transportation of individual items and packages, particularly where steep inclines can cause slippage of the goods being conveyed. As with their chevron counterparts, they are single, homogenous structures, which is relatively easy to achieve with low profiles because the rubber only has to flow a small amount compared to high chevron profiles.

Yet again, the key influencer as far as performance and value is concerned is the quality of the rubber. In this case it is ability of the rubber to resist wear (abrasion) and to resist the effects of ozone & ultra violet that are the most crucial.

Certainly as far as Dunlop is concerned, achieving working lifetimes as long as five years or more are not uncommon.

Anti-slip belting

Belts that have anti-slip surfaces such as Dunlop Rufftop are also classed as profiled belting. However, unlike their higher profile cousins, virtually all belts with anti-slip surfaces are made in the same way using various kinds of (fabric) impression during the vulcanization process. This is achieved by placing a carcass consisting of layers of fabric reinforcing ply and covered by uncured rubber compound on the top and bottom surfaces in either a conventional flat press or a slowly rotating drum press known as a Rotorcure. A specially engineered heavy-duty fabric with the desired anti-slip surface is then inserted so that the top cover surface of the base belt is pressed into it during the press cycle. Once vulcanization is complete, the master pattern fabric is then removed and used again. A similar process is used to produce anti-slip matting such as Dunlomat, which has two different anti-slip surfaces on either side. To achieve this, two additional fabric raised profile fabrics are introduced on either side to create the two different fabric impression anti-slip surfaces.

Chevrons as high as 25mm or 32mm can wear almost completely flat in a remarkably short time.

Don't be fooled

When it comes to anti-slip surface belting (and matting), appearances can be very deceptive. The same also applies to profiled belting of all types. The surface of one belt may look virtually identical to another belt. The basic specifications such as tensile strength and number of plies may also be identical. Therefore, expecting that the actual performance and working lifetime (whole life cost) will be roughly the same seems to be a reasonable assumption. However, there is often a significant difference in the asking price. Actually, there is a very good reason why one belt can have a dramatically lower price compared to one of a seemingly identical specification. And that reason is very easy to explain. Ultimately, the difference in price will come down to the quality of the rubber, which in turn will have the biggest bearing on performance and the working lifetime of the end product.

The rubber used for conveyor belts usually constitutes at least 70% of the material mass and is therefore the single biggest element of cost when manufacturing a conveyor belt. Consequently, in the highly price-competitive conveyor belt market, it automatically becomes the single biggest opportunity for manufacturers to minimize costs so that they can compete for orders based on price rather than performance and operational longevity.

Still going strong – a five-year old Dunlop Multiprof belt in action.

The slippery slope

The two most common methods used to keep rubber costs to an absolute minimum are the use of recycled rubber (usually of highly questionable origin) and the use of cheap 'bulking' fillers such as chalk to replace part of the rubber polymers in the rubber compound. Another practice is the burning of used rubber car tyres to create a cheap form of carbon black. Some 20% of rubber compound is made up of carbon black so it has a notable impact on the overall cost of making a conveyor belt. Good quality carbon black is created by a process of burning oil in a strictly controlled, low oxygen environment so that combustion is incomplete. But burning used car tyres not only pollutes the atmosphere, it also means that any oils and greases contained within 'regenerated' materials rather than good quality carbon black will have a detrimental effect on the anti-slip properties of the rubber. One of the best examples of this is found in the matting used by indoor tug of war teams. The result has been that Dunlop's Dunlomat tug of war competition matting is recommended by TWIF (Tug of War International Federation) and has become the number choice around the world. Other mats look very similar but they simply do not have a comparable level of grip.

Key messages

Making profiled belts that do what they need to do and, arguably most importantly of all, give the best return on investment by providing the longest possible working life, is something very few manufacturers can achieve. However, the engineers in Dunlop have long proved that it really is possible to have the best of both worlds.