



PHOTO: CLAYTONS OF CHESTERFIELD

Footwear Fundamentals

LEATHER – THE ESSENTIAL RAW MATERIAL

Leather is our oldest shoemaking material. From the earliest hunter-gatherers down to the modern day, animals' flesh has formed an important part of man's diet and their skins a weather-resistant covering for his body. He also soon found ways to preserve these skins from decomposition and, over time, gradually discovered new substances and techniques that enhanced their strength and utility. The concept of turning hides into leather by the process of tannage had been born.

Most of us in the footwear industry like to think we have a reasonable working knowledge of leather. Like all natural materials however, it is a complex and often unpredictable material that can spring unpleasant surprises on the unwary or unknowing. It is therefore useful to understand some of the problems the tanner faces when converting a raw hide into a finished skin or side of leather. It is also helpful to understand how the tanning process exploits the basic nature of a hide to produce leather that can be made into sound shoes as efficiently as possible.

ANIMALS ARE NOT FLAT

It is obvious to anyone that animals are three-dimensional. What is perhaps less obvious is that when the hide is removed it is also not completely flat.



Neither is it the same in regard to substance or texture in every part. Not only is the hide fully contoured to the shape of the living animal, some parts, such as the belly area, need to stretch far more than the area along the back as the animal moves around. The former is therefore more elastic, while the latter is thicker, denser and has less extension.

Neither are hides even in substance. The areas around the belly and into the legs (shanks) are much thinner than those of the back and neck. Raw cattle hides can in fact vary from 3mm to 8mm from belly to butt on those taken from cows and as much as from 4mm to 12mm on the much larger steers. If material of this thickness and irregularity was turned into leather, it would be of very little use to the shoemaker.

Size also varies enormously depending on the source of the hide and, in addition, no two hides are ever the same

Figure 1: Splitting the hide to substance

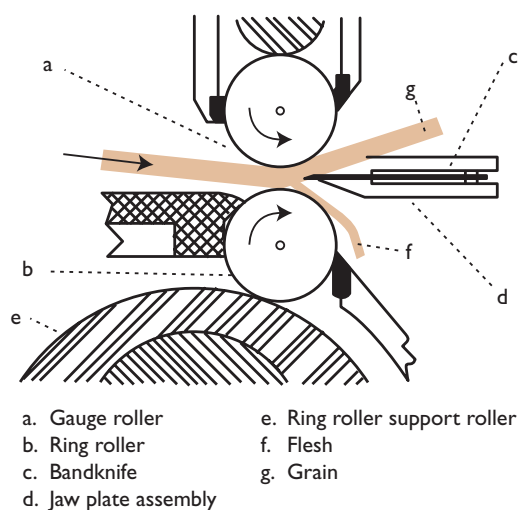
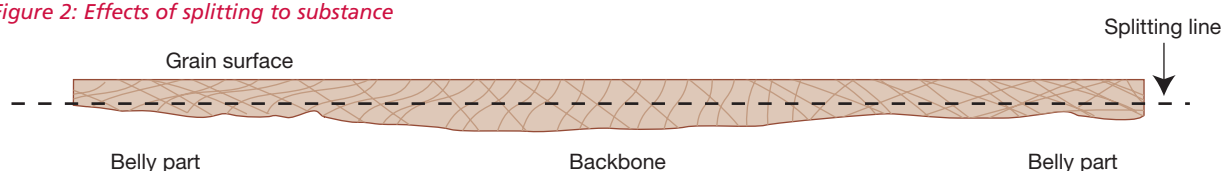


Figure 2: Effects of splitting to substance



regardless of the breed of the animal. The tanner's dilemma is therefore one of turning this oddly shaped and infinitely variable source of raw material into flat leather that has the uniformity in substance, elasticity and shape-retention that modern shoemaking demands.

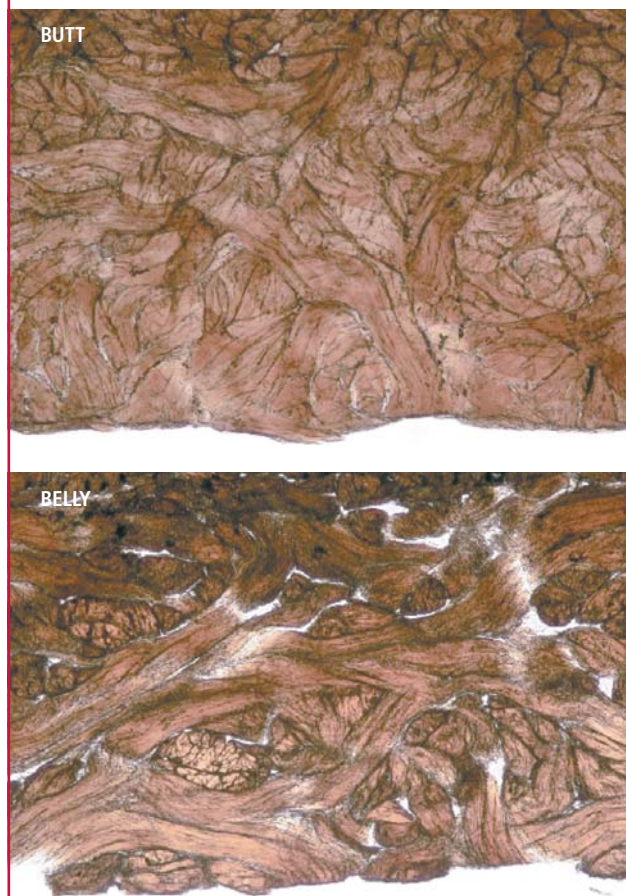
CREATING A FLAT MATERIAL

The basic tanning process that is carried out in what is known as the 'Beam House' sequence of operations sets out to achieve this and, although tanning agents and chemicals have changed over the years, the process remains essentially the same as it has always been.

First comes liming to remove any hair. This also causes swelling and an opening and separation of the fibre structure which, in turn, encourages the skin to become flatter. It is followed by fleshing to remove the unwanted membrane-like tissue from the flesh side of the hide, which restricts movement, especially in the extremities such as bellies, shanks and the growthy areas found in the neck. It also helps the hide to relax further. The next stage, de-liming or bating, where the hide is washed clean, continues this effect and, with any degreasing that might be found necessary, both stabilises the hide and helps it to retain a flat grain surface for ensuing operations.

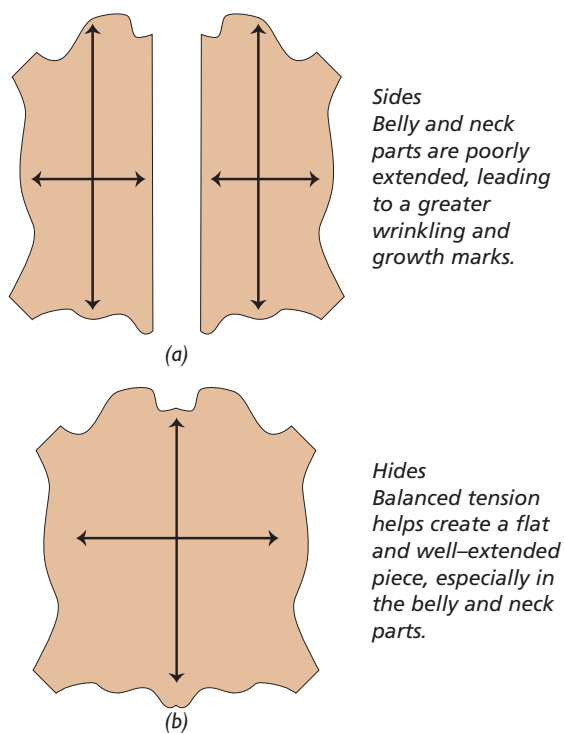
Although the hide is now much flatter, it is still far too uneven. This is resolved by splitting it down to a set overall substance (*Figure 1*). The band-knife cutting through the fibre weave causes further relaxation, a gain in area and encourages the hide to lay flatter still. This shearing effect is naturally most severe in the thicker parts of the hide where its structure is denser and there is a higher angle of weave (*Figure 2*), thus creating greater overall uniformity. ➤

Figure 3: Comparative fibre structures



The considerable differences in density and angle of fibre weave can be clearly seen in these cross sections of a hide. Selective placing of chemical products during the tanning process helps produce a more uniform substrate.

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Figure 4: Comparative tensions

Further levelling of stretch and elasticity can also be introduced during the actual tannage and retannage processes, as the more open parts of the hide such as the belly areas can be selectively filled in order to reduce their natural elasticity (*Figure 3*). The subsequent operations of setting and drying all continue to create as level and even a piece of material as possible, ready for the finishing operations that will produce the final leather ordered by the shoe factory or specifier.

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One of the key properties that has made leather so successful over the centuries is that it develops dimensional stability as a result of first-time drying. Once dried, if it is stretched then allowed to relax, it will return to its original dimensional form. Its shape is therefore largely maintained throughout the remaining leather-making process, and, while total uniformity can never be achieved, the final fully finished leather is flat and overall variations in elasticity and set have become both predictable and manageable, something the shoemaker is able to exploit.

ESSENCE OF TANNING

Whereas a piece of tanned and finished leather is flat, a shoe has a complex three-dimensional shape. Furthermore, once this shape has been formed, it must be retained throughout the useful life of the shoe. At first sight this would appear to be impossible but, fortunately, nature plus some further help from the tanner again makes it

something the shoe manufacturer can achieve.

Leather is a unique material in that it combines both 'elasticity', which enables it to be stretched into different shapes, and 'plasticity', which allows that shape to be retained or 'set'. But what causes this to happen in the natural raw state and how is it retained in the tanning process?

Expressed in the simplest terms, skin is mainly comprised of collagen chains, plus water, keratin and various proteins. Its strength comes from the collagen-based fibre weave, which is in turn lubricated by molecules of 'free' water to provide the degree of flexibility and elasticity necessary for the animal to be able to move around freely. In addition, there is also 'bound' water, which forms part of the protein structure itself. If this is removed by excessive drying of the hide, the whole structure begins to harden because of cross-linking of the collagen chains.

Tanning is therefore essentially a process whereby bound water is replaced by tanning agents as the lubricant needed to maintain the essential physical qualities of the original hide while, at the same time, preserving it. Unwanted products are removed and replaced by ones that prevent bonding between the chains of collagen so that the overall structure remains soft and flexible. Although it appears contradictory, beam house processes involving water actually cause a breakdown of weaker bonds within the protein structure and a release of bound water. This in turn softens the hide and increases its ability to extend more easily.

Water is also an important tool for the tanner in other ways. If dry leather is placed on a vacuum drying plate for a short period, the level of grain flattening is far less than if had been slightly dampened. Slight dampening also improves extension during toggling when the leather is stretched out flat on a frame to set and, at the same time, helps to ensure that flatness is retained.

HIDES VERSUS SIDES

One other factor also affects the way in which leather behaves. We have already remarked how hides vary in size and that the larger ones from steers are often split down the backbone into two halves known as 'sides'. This makes handling in both the tannery and the shoe factory that much easier. However, it does lead to a noticeable difference in the natural directional stresses between a side and a hide (*Figure 4*).

When a side is processed in the tannery, because the length is approximately twice the width, more tension is applied lengthwise than across so that there is a bias towards lengthwise stress. This also generates a degree of curvature from backbone to belly. In the case of a full hide, the tension is fairly uniform across its entire area. This tends to pull out wrinkles far better around the belly area and growth marks in the neck. There is also less distortion of the hide in total. While this might not appear important, it can make a considerable difference in how the leather has to be cut into upper components in order to take advantage of the directional properties of the particular material.

RESTORING SHAPE

When completely dry, leather can withstand temperatures well in excess of 100°C without breaking down. However, if moisture is applied it becomes more pliable so that considerable and permanent deformation becomes possible. This will continue until a critical level of moisture content is reached and massive shrinking occurs. It is this special quality, allied to the inherent mix of natural elasticity and plasticity previously mentioned, that has enabled shoemakers across the centuries to produce such a wide variety of footwear as it allows us to mould a shoe upper over a last that is complex in shape. Provided the upper has been allowed to dry thoroughly and 'set' by either natural or artificial means, it is also what ensures the finished shoe retains that shape after the last has been removed.

Shoes were traditionally made from as few pieces or sections as possible to save on patterns. The hand shoemaker was also able to apply considerable force in all directions so that as long as the upper had been sufficiently wetted, he was able to pull quite large sections down to the last. And, as long as he left the finished shoe on the last until it was thoroughly dried-out, it would retain its shape. This was only possible with leather as no other natural material behaves in the same way.

The same basic draughting and lasting principles are used on modern combined lasting machines. However, shoe uppers are now cut with far more attention to reducing the force needed to pull them down to the last

through pre-shaping them by the clever use of springing or careful placing of seams. Most leathers can actually be moulded to a reasonable degree of shape using heat only and this fact, allied to modern pattern cutting techniques, has also meant that little if any moisture needs to be introduced. Heat is still needed however to create the 'set' that is essential if the shoe is to retain its proper shape.

IMPORTANCE OF LEATHER

This unique material has formed the basis for the footwear industry from the very beginning to the present day. No other material behaves in quite the same way or offers anything like the same variety in terms of substance, texture and performance. While modern microfibres are both highly uniform materials and have come closest yet in imitating leather in terms of comfort and durability, they have yet to offer the sheer diversity of choice that leather does.

There were gloomy predictions in the late twentieth century that demand for leather would exceed supply and that we would be forced to resort to synthetic substitutes. This has failed to come about and, as the world's economies prosper, so general standards of living have improved with meat being more widely consumed than ever before. Leather as a prime by-product is therefore likely to remain freely available and, despite all its complexities, to maintain its place as the footwear industry's preferred upper material for the foreseeable future. 🍷

