



Back to Basics: A Framework for Leather Manufacture

Richard Daniels and Walter Landmann

Dry, flat and extended leathers: Part 3

Developing the properties of first-time dried leathers

After first-time drying, when a low moisture content is achieved and the temperature is lowered to ambient conditions, the leather structure has been reconfigured.

The removal of water during this period can be divided into three stages:

- Water is mechanically squeezed from the structure, mainly through machine operations.
- 1st-Phase evaporation, when physically held water is removed from the structure.
- 2nd-Phase evaporation, when chemically bound water is removed.

Although the properties of the leather have been developed throughout wet processing, these can be modified to a large extent during 2nd-Phase evaporation. The more severe the stress and strain within the leather at this time, the lower the angle of weave that develops within the matrix, and the closer the fibres are brought together. The closer the fibres and fibrils are, the greater the physical and chemical bonding that occurs. Scope for further development of leather properties is thus highly dependent upon the conditions that prevail during this critical period.

HIGH STRESS—STRAIN CONDITIONS

If high strain and stress are applied and maintained, then the dried leather will be set in a very flat, hard and extended form. This will be reinforced if high temperatures are used at this point in time.

Definition of terms

Elastic behaviour: When a force is applied, the material will stretch and store the applied energy. On release, the energy causes the material to return to the original form.

Plastic behaviour: When a force is applied, the material will stretch, but use the energy to deform permanently. On release, the material remains in its new configuration.

Strain: Distortion due to forces applied. Relates change in dimension to the original dimension, and for these purposes expressed as a percentage.

Stress: Force per unit area acting on a material and tending to cause strain.

Set: Percentage residual deformation after removal of force and after a period of recovery.

Stretch: this is a general term used when a material is extended. It does not specify extension in terms of uniformity, percentage or direction.

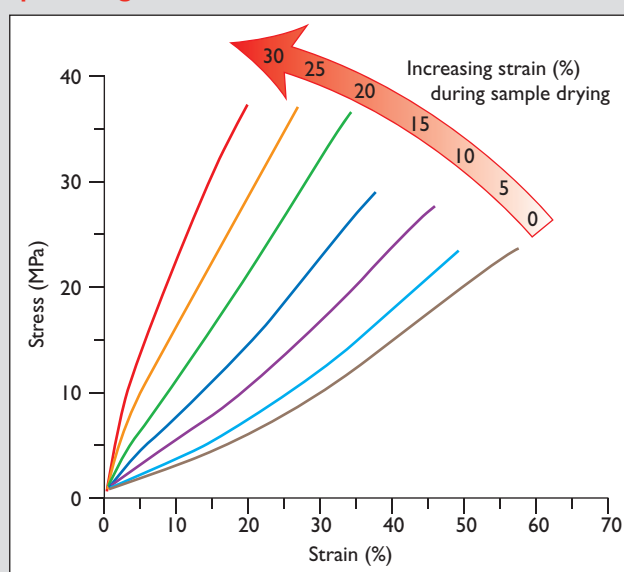
Even if the moisture content is raised within conditioning—to make the structure more malleable—considerable force will be needed to achieve any mechanical softening and, even then, the outcome can be very limited. Furthermore, when the conditioning moisture is evaporated in second-time drying, even if conditions that are free from stress and strain are applied, the leather will remain hard with low stretch characteristics.

LOW STRESS—STRAIN CONDITIONS

Alternatively, if the leather has been subjected to more moderate conditions, then the more relaxed configuration will allow for a considerable change. When mechanical force is applied, such as a heavy staking, the leather can be easily distended and become very soft, with the grain structure remaining tight and fine across the piece. When second-time dried—if free from strain—there can be considerable shrinkage as the structure is not set as strongly.

These moderate conditions result in a part retention of the natural rounded animal form which may require flattening. This can only be brought about if the moisture content is high on offer to second-time drying, as the improvement in elasticity enables greater strain towards the flatter form. Nevertheless, this new configuration can only become permanent (*or set*) if the effects of the strain and temperature applied are more severe in total than the conditions experienced in first-time drying—which will lead to the leather becoming firmer.

Panel E17/10: Stress-strain curves from tensile testing of wet blue leather strips dried under various percentage strains.



The curves are based on wet blue leathers. Retannage and fatliquoring will change these values, but the underlying characteristics are strong and apply to all first-time dried leathers.



Limitations to developing properties after first-time drying

The information shown in *Panel E17/10* gives an insight into the limitations imposed by first-time drying on subsequent change where:

- Each of these dried wet blue samples was prepared under different conditions. When wet, these samples were strained to 0%, 5%, 10%, 15%, 20%, 25% or 30% and this strain was then maintained as the leather dried out at room temperature.
- This percentage strain is shown on the graph as a rising value (*red arrow*) and

corresponds to each dry wet blue sample as appropriate.

- The curves show the stress required to strain strips of dried wet blue leathers up to the point of structural failure.

This shows that for the dried samples, the higher the strain maintained throughout the drying of the wet blue samples:

- The greater the stress required to achieve a specific percentage strain.
- The lower the strain that can be tolerated before rupture of the fibre structure.
- The higher the progressive increase in hardness and inflexibility.

These measurements were based on wet blue leathers and, in practice, the excessive hardness of dried wet blue needs modifying by retanning and softening agents. However, these characteristics are easily recognised within all leather production where the more severe the stress throughout first-time drying, the harder and more dimensionally stable the outcome.

Clearly, the conditions applied between the wet and first-time dried state need to complement the leather properties that have been carefully developed in the wet process work. If all is in balance, then mechanical softening can develop the correct degree of softness required while maintaining the finer aspects such as a good break and smooth grain texture.

If the leather has been dried under conditions that are too severe to achieve a required character, the leathers may require more stress and strain than the structure can tolerate. In this situation instead of softening as a result of fibre separation, there is a rupturing of the structure. This causes a coarse break, especially in more sensitive parts such as the belly, shoulder and axilla. If taken further a harsh grain texture develops as the grain is over-stressed, and if taken to excess this can lead to cracking or even tearing deeper within the structure.

In contrast, less stringent first-time drying conditions produces leathers that are inherently softer and can better tolerate force. But, in this situation the leather may become too soft and misshapen, although some rectification is possible by increasing the severity of second-time drying.

To summarise, the conditions of stress, strain and temperature during 2nd-Phase evaporation strongly affect the properties carefully developed through wet processing. At the end of first-time drying, the character of the leather is strongly developed; the more severe the conditions the greater the permanence of these properties. Small variations within first-time drying can cause a significant shift in leather characteristics. In this event it may be that adjustment in subsequent operations is insufficient to meet the final requirements of the leather, in terms of both handle and quality. 

Acknowledgements

E17/10: The influence of first-time drying on the characteristics and performance of leathers: G.E. Attenburrow, British School of Leather Technology, University College, Northampton, UK: World Leather August/September 2005.

Panel E17/11: First-time drying to a moisture content suited to staking

During first-time drying, it is usual to dry leather to a low moisture content. This is for two reasons:

- The structure of leather is very varied in terms of both voids and chemical distribution within the matrix. This results in an uneven release of water from the structure during mechanical operations and by evaporation.
- The removal of water is non-uniform as a function of the drying equipment. For example, the movement of air both within a drying unit, and between individual skins may be irregular. In addition, the airflow across the centre parts of skins within a unit is less than across the more exposed edges.

This means that the different skin parts dry at different rates. If a moisture content of, say, 28-30% was considered ideal for staking, although some parts of the skin might be dried to this level, other areas would be either too wet or too dry. So it is customary to dry to lower moisture contents. As the leather becomes drier, not only does the moisture content become more uniform across each piece, but also throughout a whole pack of leather.

The leather, therefore, needs re-wetting or conditioning before staking. On first consideration, it would appear ideal if leather could simply be dried to the staking moisture content.

This is managed for some types of leathers, although normally it involves a drying at almost ambient temperatures. However, for most types of leathers, the development of a flat and extended form first requires the maximum degree of elasticity—high moisture and temperature—to enable extension of the leather. Once dry, the leather requires the maximum plasticity—that is, low moisture content and cool conditions—to maintain the new configuration.

If the objective is to maximise the flat and extended form, it is therefore important to dry to a low moisture content to gain plasticity. If leathers are only dried to the staking moisture content, then, as this favours greater elasticity, on release of stress there will be a relaxation that will result in reduced flatness and area.

To take matters further, leather is normally removed from the drying equipment while still warm. If the objective is permanent flatness and area retention, after drying under strain, the leathers should not only be at a low moisture content when removed from the drying equipment, but also cool. This is not common practice, but it is interesting to note that the objective of paste drying was to make flat and extended leather, and part of this operation originally included a cooling zone (normally sacrificed in practice to gain extra throughput).

So, although it may appear ideal to directly seek conditions suited to staking, this simply concerns the removal of water. First-time drying is far more complex, being central to the fine management of elastic and plastic properties.