



Back to Basics: A Framework for Leather Manufacture

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The effects of forces applied within leather finishing

This Essay provides an overview of effects stemming from finishing operations. There are many exceptions due to variations in the properties of pre-crust leathers and the complexities of finishing. For this reason effects detailed here should be regarded as general.

The properties of the finish film are strongly dependent upon the properties of the finishing components and the way that they are brought together in film development. This involves the application of physical forces, and often requires shifts between elastic and plastic behaviour.

These shifts are mainly temperature controlled, as low moisture content within the finish film is demanded. The structure and physical properties of the underlying leather are mainly established at the pre-finished state, but the step-by-step requirements of finishing can strongly amend these properties.

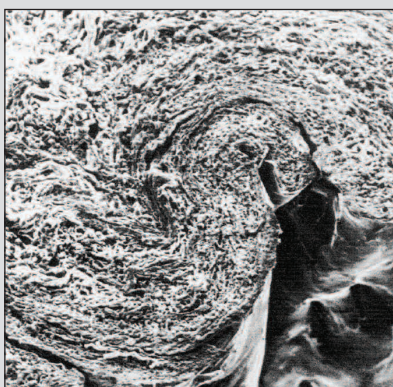
Essay 25: Parts 1-7 provides an overview of finishing equipment and application techniques, but with specific focus on the objectives of each method that might be employed. These descriptions are important as the outcome from each mechanical action affects finish development, hence the properties of the finish film, and often the underlying leather structure.

The properties of a finish film

The formation of the finishing film is a complex operation. The properties of the binders used are strongly moderated by the properties of other components within the application. Apart from cross-linkers (*encourage strength and flexibility*), every additive reduces the potential strength of a film created by that binder. And additives other than solvents and wetting agents reduce the strength of bondings between the various coatings as the finish is developed^(2,3).

Further, the properties of each finish application need to be different. The emphasis is initially on bondings between

Panel E26/1^(a): The break characteristics of leather on folding



The ability of the fibre weave under the grain surface to readily extend or compress on folding ensures a fine break.

Restriction within this delicate structure by excessive coating on finishing or fibre compression causes deterioration in this valuable property.

grain and finish, then intercoat adhesions, and finally on the topcoat for protective/visual/tactile effects. These final properties are strongly affected by the way that the finish is applied and developed, and this includes the control of mechanical forces.

Finish coat applications

The build up of the finish film can be viewed in two stages:

1] FIRST COAT APPLICATIONS

This provides the bonding between the finish being applied and the surface of the leather. Regardless of the composition of the finish blend and the amount offered, an increase in mechanical action:

Within film formation:

- causes an increase in penetration of the finish into the leather surface,

- improves the bond between the grain layer and the finish, that is, it increases the adhesion of finish to the underlying leather.

On the underlying leather:

- increases the penetration into the grain structure,
- increases the depth of grain swelling with aqueous finishes.

Once the film is dry, these changes may be seen as:

- loss of smoothness of the grain surface (*more correctly the surface of the leather-film combination*),
- difference in the break characteristics
- hardening of the leather,
- a reduction in the lastometer distention at crack and tensile strength,
- reduction in water vapour permeability.

Additional effects:

- These differences in break characteristic are complex and strongly dependent upon the technical properties of the film. If the binder is suitably soft, then with good penetration into the surface of the leather, and sufficient filling of the fibre voids in the grain layer, the break characteristics can be better maintained by subsequent finishing. This is central to leather impregnation: if the penetration is insufficient, then an overfilling at the surface causes deterioration in break. The loss of grain smoothness as a result of impregnation is best rectified by light buffing. This leaves a smooth but finely abraded or corrected surface as an assist for the physical locking of subsequent finish applications, whereas plating/rolling and polishing only flatten the surface.
- Where, the system does not rely on impregnation, the finish penetration is restricted to the surface otherwise there can be a significant loss of break characteristics. Flattening of this new surface is dependent on heat and pressure from pressing operations.



2] SUBSEQUENT FINISH COATS

Bondings occur between the finish film being applied and the previous finish layer. Greater mechanical action as an aid to intercoat diffusions improves the bondings, and reduces the danger of intercoat adhesion weakness or failures.

The coarsening of grain break is due to the technical properties of the subsequent film, also its thickness.

As the film thickness increases, there is a greater risk of abrasion damage⁽⁴⁾. In turn this increases the risk of peeling of the finish in wear either by intercoat failure or at the grain/finish junction: the adhesion values are not affected (*unless there is water penetration, hence swelling/weakening of the film*) but the opportunity for peeling is increased. There are further losses of water vapor permeability.

Drying operations (all stages of finishing)

Loss of water occurs from the time of wet finish application by both surface evaporation and migration into the leather. This loss is essential as part of coalescence within film formation and the development of physical properties within that film. This moisture loss also reduces platten-finish adhesions on plating/rolling/printing operations as it reduces the plastic behaviour of the film. Drying involves water loss from both finish and leather, so:

Within film formation:

- the physical properties of the film are optimised,
- there is a reduction in potential bonding between the film and subsequent finish applications.

On the underlying leather:

- there is a hardening under very rapid drying conditions,
- Gentle air drying minimises hardening,
- there is a loss in area and thickness.

Additional effects:

- The faster the rate of drying the greater the danger of moisture encapsulation within a heavy finish layer with associated instabilities as the film forms, including "caking effects".
- Drying by modified infrared radiation drying focuses on the finishing film so the effects of water removal from the leather, along with associated effects are reduced.

Plating, rolling and embossing operations

Higher temperature used during these operations cause a strong shift from elastic to plastic behaviour. The greater the pressure and the longer the dwell time the greater the outcome from these pressing operations. On removal from the operation the temperature drops, ensuring that the new form is largely maintained. The outcome from this operation requires a balance between temperature, pressure and time, and an increase in any one of these elements causes:

Within film formation:

- an increase in finish smoothness,
- increase in finish-plate adhesions,
- the possibility of reduced bonding between the film and subsequent applications.

On the underlying leather:

- a greater compression of the fibre structure - that is a loss in thickness,
- a hardening of the structure,
- a reduction in break characteristics,
- a marginal increase in area.

Additional effects::

- a reduction in the degree of stretch under a given load,
- reduced tensile strength,
- reduced lastometer readings,
- significant reduction in water penetration time in waterproof leathers,
- increase in water uptake in waterproof leathers,
- high temperatures cause significant hardening if the moisture content in the leather is too high, accentuated by long dwell times.

On embossing:

In addition to comments under "Additional effects" -

- Heavy embossing improves the break characteristics throughout the whole structure as the normal folding/compressions are overridden by the newly created patterns.
- Light embossing, such as sandblast-type and haircell effects cause an improvement in surface break as folding effects are disturbed at the grain layer.



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The overall effect of finishing on the final leather

As stated previously, the shifts in properties described must be viewed in general: they range from significant to marginal, and there will be exceptions. These shifts are influenced by the technical properties of the finish film, and the mechanical operations employed. Padding, roller coating, curtain coating, various types of spray applications - all affect the film development and bonding properties but have little direct influence on the underlying leather form. Operations that cause compression affect both the properties of the finish film and the leather structure.

Over and above the role within film development, the drying operations cause significant changes to the leather substrate. Although leather characteristics are firmly developed by the pre-finished state, water losses from the leather occur throughout finishing, and this causes change in properties.

Where convection drying is used within finishing the loss of moisture from leather can be considerable, and high temperatures can lead to significant leather hardening. Modified infrared radiation drying focuses on the finish film thus minimising these effects.

Moisture losses can be from >14% in pre-finished leathers to <10% at the finished state, causing a loss in area. This might range from perhaps 1% loss in firm dimensionally stable leathers to 5% in very soft thin leathers. Losses in thickness will be small compared to reductions in substance due to plating/rolling operations.

Milling finished leathers can cause significant area loss, dependent upon mechanical action, temperature and relative humidity. It should be noted that area losses due to high moisture loss is exceptionally difficult to reverse even in part. Rewetting and toggling may have slight effects on area gain but the original area can never be regained⁽⁵⁾.

Acknowledgements/additional information

1) Panel E26/1: Photograph by Betty Haines, from "The Fibre Structure of leather", courtesy the Leather Conservation Centre, Northampton, UK.

2) The use of solvents (other than water) and wetting agents in finishing involves issues of diffusion and coalescence in film formation. Solvents (and water) are subsequently lost by evaporation.

3) An in-depth study on the formation of the finish film is provided by the paper entitled "Adhesion and leather finishing", by Dr J. Guthrie-Strachan, World Leather August/September 2008.

4) Exception: patent topcoats

5) The effect of moisture loss on area and substance is detailed in the paper entitled "Yield, quality and physical properties of leather Part 3 of 3: The effect of moisture and temperature on dry leathers", R.Daniels, World Leather February/March 2009.

6) Discussions and technical details: thanks to A. W. Landmann, P.Evans, C.Barnard. 



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