Society of Leather Technologists and Chemists

Leather:

AN INTRODUCTION

Richard P. Daniels

Preface

This study is for general interest, and people who are new to the sector and need a better understanding of leather.

It describes the versatility of this unique material, its natural origins, how it is made, and why its properties are so comprehensive.

It enables comparisons with plastics, laminates and conglomerates of binders/natural materials - as long as their origins, composition and environmental profiles are similarly detailed.

This document was subjected to peer review at the International Conference of the Society of Leather Technologists and Chemists, Northampton, UK, 2019.

Content

What is leather ?

Bags and leather goods.

Fashion and day wear.

Leather has many everyday uses

Individuality and lifestyle.

Comfort and performance.

- both new and traditional

Refined beauty with easy care.

Rugged belts and equestrian uses.

Hides and skins – the basic raw materials that leather is made from – and leather have exceptional properties.

For example:

Unprocessed skins can be strong and shatter-proof

A cannon made from dried hide !

Leather can be water resistant and durable

Across the Atlantic in an all leather boat !

Provide protection, comfort and insulation

Extreme footwear: Hygiene and anti-bacterial properties, perspiration resistance and water vapour permeable.

Flexibility at very low temperatures

Protection for exposed hydraulic components:
Gloving and industrial applications:

Temperatures down to -50C.

Provides fire and heat protection
+ resistance to acids and alkali

Military, security and industrial applications.

Security of performance

Resistance to tearing and abrasion.

Soft, tough and tactile.

Longevity

Coptic Holy book – pages made from parchment.

Leather:

- A high-tech fabric based on a natural raw material.
- Offers impressive physical performance combined with classic aesthetic characteristics.
- Alternative fabrics and materials often can achieve higher standards in individual physical performance, however, their broad range of properties can be very limited.

Natural resources

The global herds and flocks are approximately: Cattle 1 billion, Sheep 1 billion, Goat 1 billion

- These animals are reared for their value in dairy products, wool and for their meat.

They are never bred or raised for their skins

Wide range of dairy products.

Washed and dried wool for baling.

- **Ultimately, skins are a putrescible waste from the meat industry.**

How much waste ?

Enough to create three pyramids each year the size of the Great Pyramid of Giza !

From global meat production *(2008 – 2017)*

(Statistics: Food & Agricultural Organisation of the United Nations)

Average each year:

- **300 million bovine hides at 25 Kg weight average.**
- **539 million sheep skins at 1.5 Kg weight average.**
- **436 million goat skins at 1.5 Kg weight average.**

Present outlets other than conversion to leather:

- **Disposal to landfill *(issues as biodegradable waste)***
- **Gelatine and sausage casings.**

Future possibilities:

- **Mechanical/chemical/biological processing for biogas ?**
- **Fertiliser or animal/human consumption ?**

But these options destroy the worlds only natural raw material that offers a usable inter-woven fibre structure !

This resource can be easily be preserved !

- Application of common salt.
- Air drying, and a light salting + drying *(dry salting)* may be used in warm or dry climates.

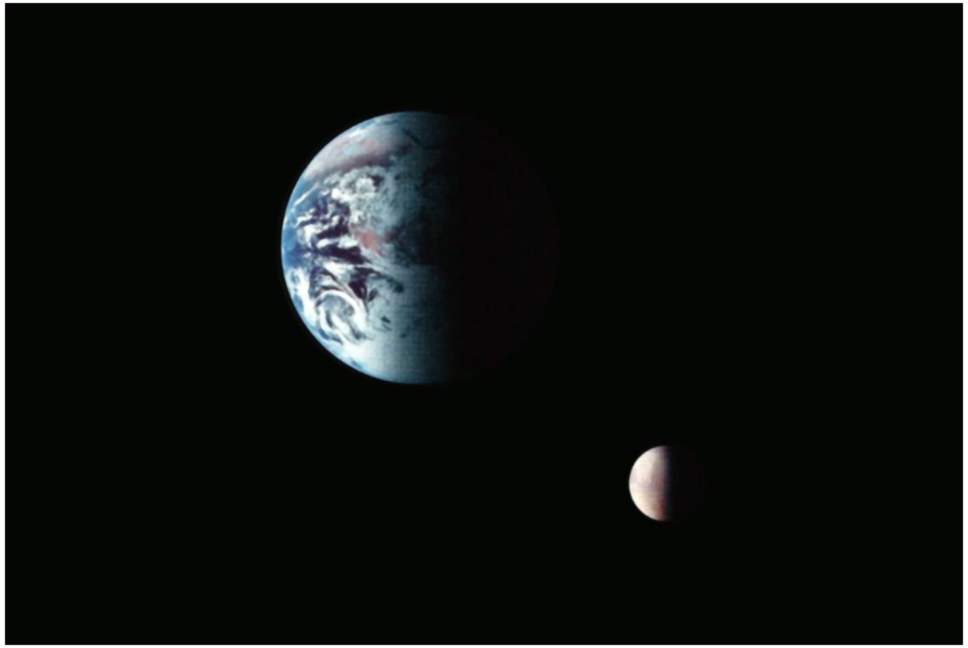
- These techniques enable transport across the world.
- Chilling is used too for short term preservation.

- <u>then converted into leather</u>

- **A natural, versatile and long-lasting material suited for a wide range of end uses.**
- **Apart from cotton and wool *(needs growing and weaving)* almost every alternative is synthetic/faux/plastic.**
- **That is, plastic based on non-renewable crude oil, and as plastic/filler conglomerates manufactured in sheet form.**
- **In contrast, leather is the worlds first and most successful example of converting a waste into sustainable products.**

Sustainability

Sustainability



The key for long term survival !

Manufacture, consumption and waste:

- **All manufacture consumes materials and generates waste. Everything that we eat, wear and use – there is no exception.**
- **Responsible manufacture can minimises problems - part of long term sustainability.**
- **This applies to leather manufacture too.**

For the leather industry five responsibilities in particular are identified:

- **Water use in manufacture.**
- **Efficient chemical processing.**
- **Residual solids from manufacture.**
- **Energy in manufacture.**
- **People / Corporate Social Responsibilities.**

Water required in manufacture

Storage of fresh water for process.

Waste water for reuse/recycling.

- **15 – 25 cubic metres required for processing one ton of raw hides.**
- **Volume minimised by good water management and applications.**
- **Can be reduced further by water recycling options.**
- **Applies to automotive, footwear, leather goods.**
- **For men's shoes (traditional leather uppers) water requirement - based on the higher value - is approximately 36 litres of water.**

0.1 sq.m leather/shoe: 138sq.m leather/1000kg hides: (Mass Balance: United Nations Industrial Development org.

Water treatment after manufacture

Biological treatment of used water.

Cutting edge technology available.

- **All of this water is returned to the environment.**
- **Requires full treatment before discharge from manufacturing site.**
- **Involves full biological treatment, and can include reverse osmosis and evaporation (95% water recovery, 5% evaporation).**
- **“Standards for Discharge” are set by Governments for legal enforcement.**

Efficient chemical processing

Precision in chemical use.

Analysis and control.

- **Careful selection of raw materials and chemicals.**
- **Usage of Best Available Technology (BAT).**
- **Close attention to control and management of the chemical processes.**
- **High efficiency chemical use without jeopardising quality.**

Residual solids from manufacture

Fish food and fertilisers.

Composting for land improvement.

- **Efficient processing, choice of chemicals / equipment and their management is used to minimise waste.**
- **Not all of the skin structure is suitable for leather making, but non-required components are segregated for alternative use.**
- **Options include grease recovery, fertilisers, methane production, hydrolysates as bio-chemicals, regeneration of chemicals, and composting.**

Energy in manufacture

Energy from used/rejected wood.

Photo-electric power too.

- Energy waste is minimised through good process control.
- Equipment is efficient and heavily insulated.
- Heat generation, air compression and leather drying equipment is efficient and well maintained.
- Close attention to carbon footprint.
- Alternative energy sources: Includes solar, geo-thermal, bio-methane, municipal waste, recovered fats/grease.

People: Corporate Social Responsibilities

Workplace: freedom of expression.

Attention to heath and safety.

- **National and international accreditation schemes.**
- **Education and training.**
- **Health and safety matters.**
- **Rights for the workforce and respect for religious beliefs.**
- **Respect and care for women.**
- **Communication and support of local communities.**
- **Care of the wider environment.**
- **Food, medical/health care and support for deprived children.**

Leather Manufacture

Leather is made from hides and skins

Hides:

Refers to skins obtained from mature cattle. These are heavy and have a large area and thickness. These are mainly used for footwear, automotive purposes and furniture, larger size leather goods, clothing and industrial applications.

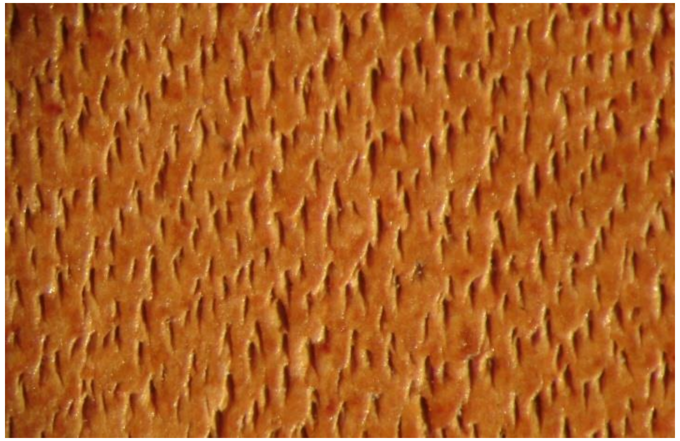
Skins:

Refers to skins from small animals such as goat and sheep. These are relatively light in weight, and have a small area and thickness. These tend to be used for clothing, footwear, bags, small leather goods, and gloves.

The structure of leather

Cross-section of a leather sample

Grain surface of a leather sample



- This cutting through a sample of leather shows the highly interwoven structure that exists within all hides and skins.
- This is central to strength and comfort in use.
- The dense top layer is known as the grain layer.
- We usually see the grain surface in leather constructions.

<u>For all types of leather manufactured, hides and skins need structural change</u>

These changes are performed in four stages:

Stage 1] Removal of unwanted materials.

Stage 2] Introduction of new materials.

Stage 3] Water removal.

Stage 4] Finishing applications.

The structure is mechanically flattened and extended too - mainly throughout stages 1, 2 & 3.

Stage 1]

THE SOAKING PROCESS

Salted hides awaiting rehydration.

Hides after cleaning and soaking.

- Hides may be preserved by the application of salt.
- Fresh and chilled hides are used too.
- The soaking process cleans and rehydrates the structure.
- Mild alkali, detergents and enzymes can be used in this first stage of processing.

UNHAIRING AND LIMING PROCESS

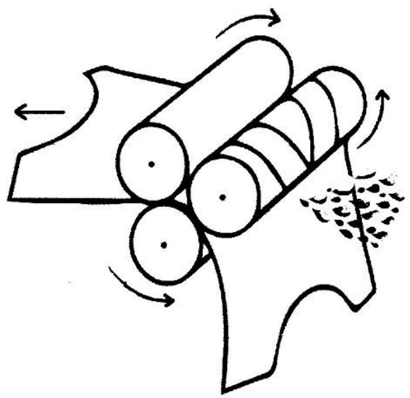
Hides awaiting hair removal.

Unhaired and alkali swollen hides.

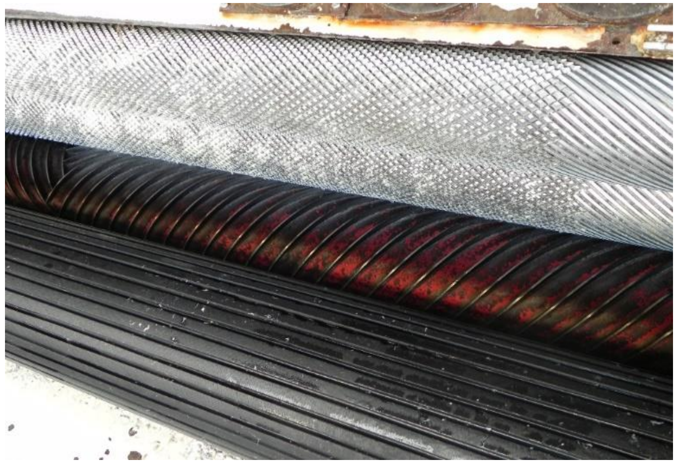
- Once the hides or skins are fully hydrated, the hair can be chemically loosened from the grain surface.
- This hair can be saved for other uses.
- The structure is then swollen by the addition of alkali.
- Unwanted proteins are dissolved in this process, and the collagen fibres in the structure separated.
- This processing ensures that the final leather has the softness required.

FLESHING OPERATIONS

Fleshing mechanism.



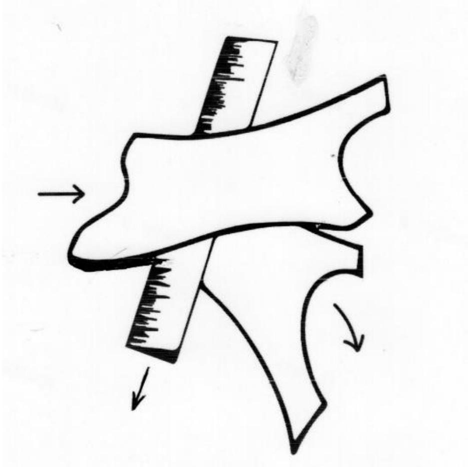
Grip rollers and cutting cylinder.



- In the fleshing operation, the inner part of the hide is mechanically pressed against cutting blades mounted on a fast rotating cylinder.
- First, one half of the piece is placed in the machine. The cylinder jaws close, and the residual flesh is removed as the hide is fed out from the machine.
- The second half of the hide is then placed in the machine and the operation repeated.

SPLITTING OPERATIONS

Lime splitting mechanism.



The lime splitting operation.

- **The fleshing operation is followed by lime splitting.**
- **The hide - being of irregular thickness - is split into two layers by feeding against a fast-moving band knife.**
- **This produces an upper section (or grain layer) of uniform thickness.**
- **This is a through-feed operation.**

DELIMING AND BATING PROCESSES

Lime split hides - uniform thickness.

Hides after deliming and bating.

- **In the deliming process the split hides are neutralised from an alkali swollen state to a neutral relaxed condition.**
- **Special enzymes - known as bating agents - are also applied.**
- **These processes cause the hides to de-swell, and release unwanted materials from within the structure.**
- **This produces a soft, clean and pliable collagen matrix.**

Stage 2] **THE ACID/SALT PICKLE PROCESSES**

Controlled acidification for pickle.

Pickled skins awaiting inspection.

- **There are many types of tannages, and each offers different properties.**
- **Preparation normally involves the application of selected acids and common salt to delimed hides in the processing vessel.**
- **Known as pickling, this process controls the penetration of the tanning agent into the skin structure.**
- **Subsequently, the collagen structure is stabilised by the addition of a tanning agent.**
- ***[Small skins – sheep and goat - are usually inspected in the pickled state to assess quality]***

THE CHROME TANNING PROCESS

Chrome tannage of hides complete.

Skins palletised after tannage.

- The most common tanning process uses chromium salts.
- Once tannage is complete, this is known as "wet blue".
- This leather is very stable: it can withstand temperatures of 100C when saturated.
- Chrome tanned leather has been used extensively since the early 1900s for a vast range of leather products.
- Includes footwear, clothing, leather goods and upholstery.
- It meets engineer-driven standards and fashion demands, providing comfort and long life.

THE VEGETABLE TANNING PROCESS

Vegetable extracts for tanning.

Extensive craft uses.

- Extracts from different types of bark and leaves are used for vegetable tannage.
- Includes mimosa, chestnut, quebracho and tara extracts.
- This is a very old tanning method, and makes mid/light brown coloured leathers.
- The leathers can be moulded, carved and embossed readily, with excellent shape retention.
- Offers high level of comfort in footwear, including strong anti-bacterial properties.
- Industrial, fashion, leather goods and craft applications.

WHITE TANNING PROCESSES

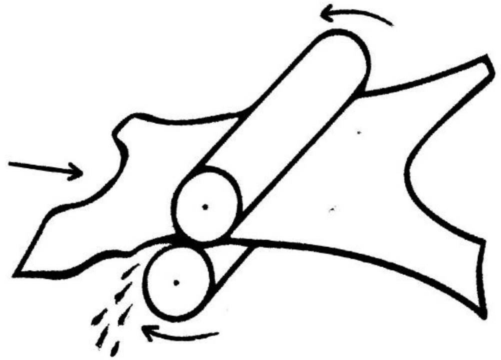
Palletised white tanned hides.

Classic executive expectations.

- There are many “white” and lightly coloured tannages.
- Tends to be thinner and firmer than chrome tannage.
- Shrinkage temperatures between 75 – 85C when saturated.
- Provides excellent shape retention for moulded fittings and components.
- Automotive, furniture, commercial aircraft and rail-carriage uses for durability and comfort.
- Easy-clean for good hygiene in heavy use situations.

SAMMING OPERATION

Samming mechanism.

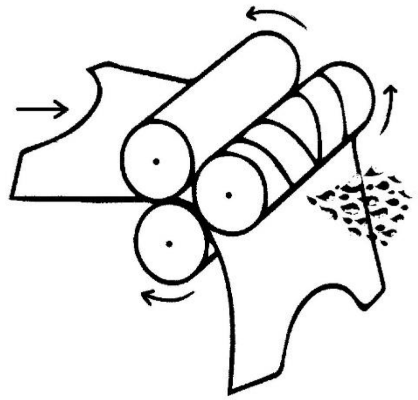


Hide-feed to samming operation.

- After tanning, the leather is lightly squeezed to flatten and part-dewater.
- This is a through-feed operation in preparation for the shaving operation.
- The lime splitting operation is often avoided, and in this event after samming and before shaving the leather is split.

SHAVING OPERATION

Shaving mechanism.



Feed to the shaving operation.

- In the shaving operation a small amount of the substrate is cut from the inner part of the leather.
- This is to ensure that when leather making is complete, the end product is of uniform and accurate thickness.

RETANNING, DYEING AND SOFTENING PROCESSES

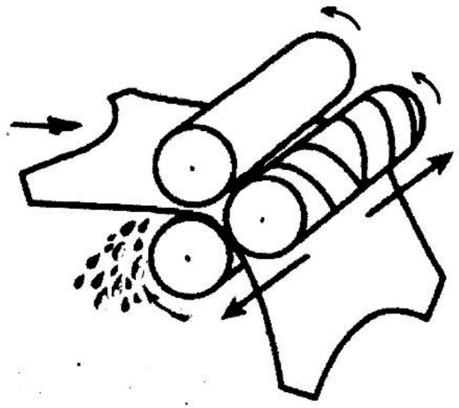
Complete range of dyeing.

Carefully stacked dyed leather.

- Specific colours and textures are introduced in these processes.
- Here, the properties of the original tannage can be modified.
- Natural and synthetic agents are used to fill spaces within the fibre structure.
- Softening products are used too, based on vegetable, fish, animal and synthetic oils.
- These are applied under slightly acidic conditions.

Stage 3] **SAMM/SETTING OPERATION**

Samm/setting mechanism.



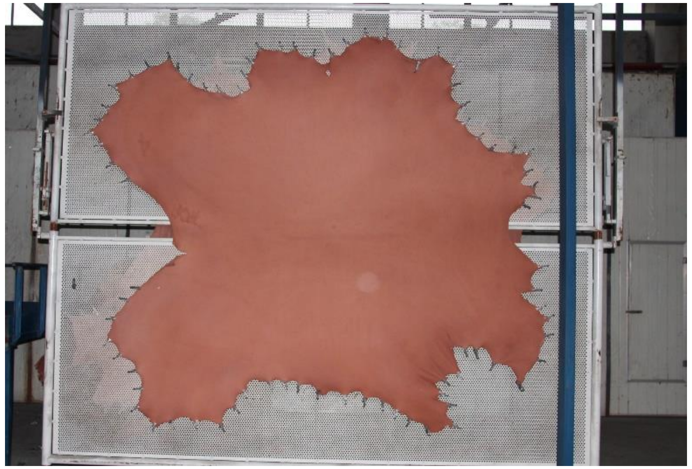
Feed to samm/setting operation.

- **Water is removed both mechanically and by evaporation.**
- **First, the samm/setting operation applies a stretching and squeezing action to the wet processed leather.**
- **This is to flatten and prepare the leathers for controlled drying by evaporation.**
- **The internal fibre structure is strongly re-aligned in these operations.**

DRYING: RELAXED AND TENSIONED EVAPORATION

Relaxed drying for softer leathers.

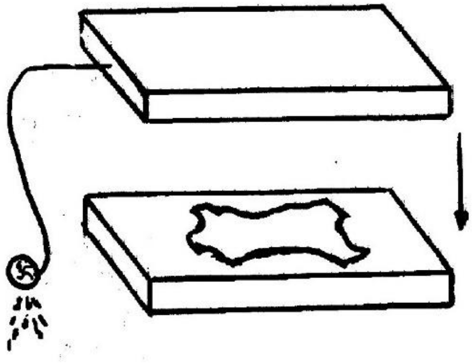
Hides stretched and tension dried.



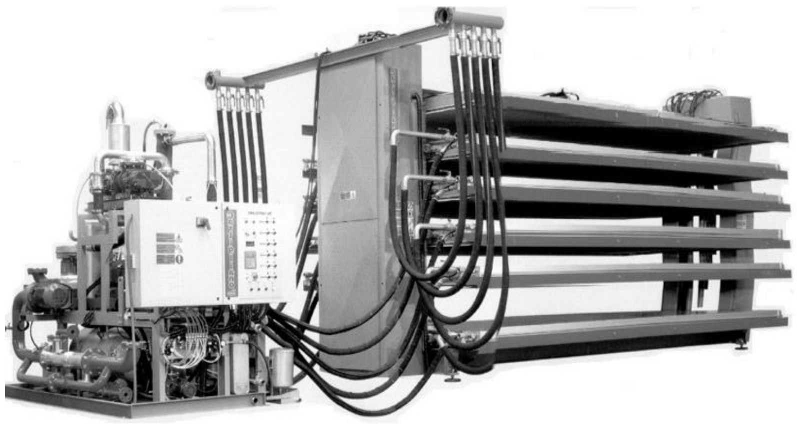
- **The softest leathers are produced by drying tension free.**
- **Drying under tension produces a firmer, flatter leather of greater area.**
- **A combination of earlier processing and drying methods determines the softness, texture, and physical properties of the different leathers.**

VACUUM DRYING OPERATION

Vacuum drying operation.



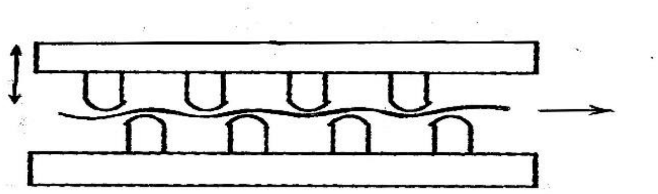
Multi-plate vacuum drying machine.



- In this technique leather is lightly stretched on a polished heated plate.
- A hood is lowered to form a seal with the plate.
- Air pressure is reduced by vacuum pump, with lowering of the boiling point of water.
- Causes fast evaporation of water + smooth grain surface.
- Normally used for part-drying.
- Water removal completed by tension-free drying.
- Many drying variations are possible.

STAKING OPERATION

Vibration staking mechanism.

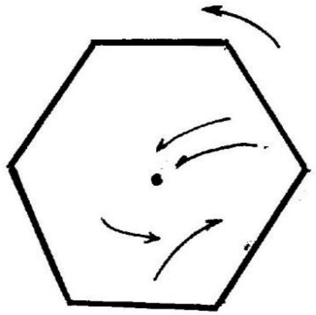


The vibration staking machine.

- Leather needs some softening after drying and mainly uses the vibration staking machine.
- The leather may need slight dampening before this operation, and if so, it receives a light water spray known as conditioning.
- Vibration staking applies a stretching and controlled hammering action to loosen the fibre structure.

MILLING OPERATION

The milling mechanism.



There are many machine variations.

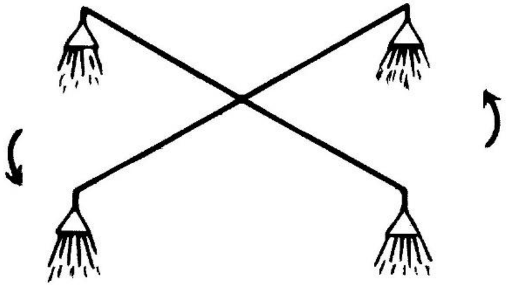
- More softening is sometimes developed by the dry milling or tumbling operation.
- Careful control of mechanical action, relative humidity, running time and temperature.
- This operation can be used to create special grain effects.

Stage 4] Finishing applications

- **Surface coatings are mainly applied to the grain side of dry leather for protection, precise colour, and for visual enhancement.**
- **Many different effects are possible to meet fashion demands and customer specifications.**
- **This protective finish is normally built up on the grain surface using a series of machine applications.**

SPRAYING OPERATIONS

Spraying (rotary) mechanism.

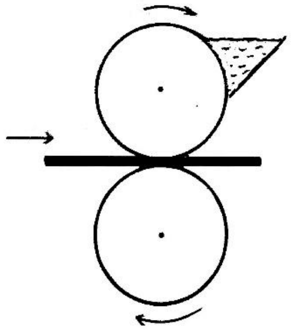


Hand-spraying test sample.

- Finishes comprise mainly colour agents and binders.
- Very light finishing may depend upon spray applications alone.
- There can be several applications to provide sufficient cover of the grain surface to a precise shade.
- The leather is generally fed into an enclosed spray cabinet supported on a stringed conveyor feed.

ROLLER COAT OPERATIONS

The roller coating mechanism.



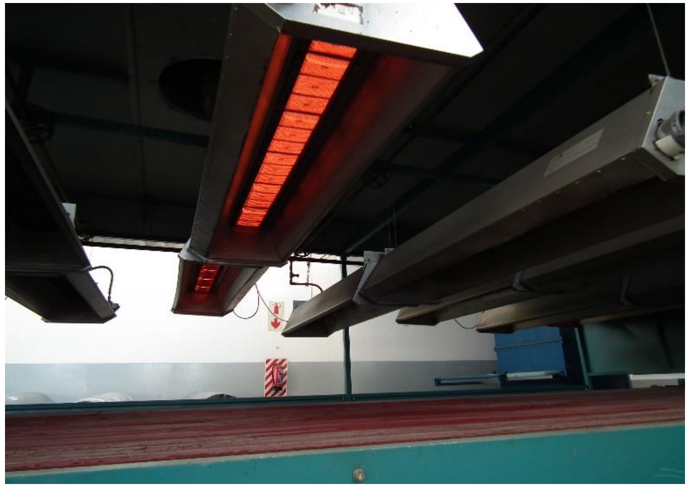
The roller coating operation.

- This is the transfer of wet finish onto the grain using a roller.
- When dry a protective film is created on the leather surface.
- There may be several of these applications.
- Spray coats are often applied after a roller coat application.

DRYING OPERATIONS

Conventional air drying cabinets.

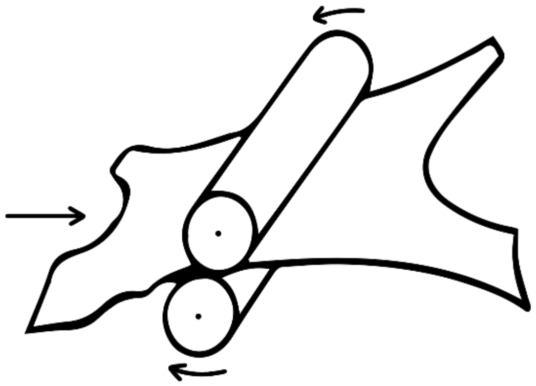
Radiant drying for film drying.



- After these wet film applications, the leathers are conveyed by machine linkages into drying units.
- Water removal is an important stage in developing film properties.
- Forced air circulation within drying cabinets using steam radiators is mainly used.
- Direct radiant drying is also employed.

ROLLER PRESS OR IRONING

Roller press mechanism.

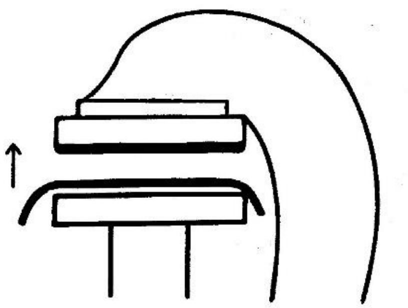


Feeding a roller press.

- Film formation is completed by the application of heat and pressure to the finish surface.
- Through-feed rolling systems are mainly used.
- The rollers may be smooth and polished, or have textures engraved into the surface.
- These different rollers create detailed grain effects.

RAM PRESS

Ram press mechanism.



The ram press operation.

- **This is a versatile operation, and considerable pressure can be applied.**
- **Smooth or engraved plates are used for this purpose.**
- **Used for developing pronounced grain effects or smaller volume production.**

Complete ranges of colour, texture, tactile characteristics, properties and effects

Leather: a blend of natural products and technology

From an irregular waste from one industry

- to a flat, versatile and sustainable material.

For more detailed information see:

Making Leather:

AN OVERVIEW OF MANUFACTURE

Richard P. Daniels

"OVERVIEW" is for people who wish to become leather technicians, and those who need to know more about leather. Created for self-training, it offers clear and precise information. It comprises approximately 30,000 words + 300 integrated technical diagrams and images.

"OVERVIEW" develops and expands the leather-making section of "Leather: AN INTRODUCTION". Presented in 10-Parts, the focus is on raw material properties, manufacturing procedures and finishing operations for the production of major leather types from:

Bovine hides, hair sheep and goat skins, wool-bearing sheep skins.

Designed for ease-of-use by the individual, and within formal education, the objectives include:

+ Better technical understanding within a diverse industry

+ A comprehensive study free of any costs or charges.

+ It's about making leather !

Peer reviewed, it is recommended by SLTC, UNIDO and IULTCS, and available on their web sites.

Credits

Images and Schematics:

R.P. Daniels: Photographs from industrial sites in Africa, Americas, Asia, China, Europe. Includes content from learning/education packages/presentations created for ICLT University of Northampton, UK: QiLu University, Shangdong Prov. China: United Nations Industrial Development Organisation: Conferences - UNIDO, SLTC, ALCA, IULTCS.

- **Cotton Coulson: The voyage of St Brendan.** ***(page 9)***
- **Phil Harley.** ***(page12)***
- **NASA/JPC/ Caltech: Galileo spacecraft 6.2 M Km 1992.** ***(page 24)*****.**
- **Micrographs specially created by Amanda Michel** ***(page 35)***
- **Unknown.** ***(pages 13,19 & 51*****).**

Special Thanks:

Paul Evans, for keeping me on track.