# STEEL MEETS LEATHER – THE INFLUENCE OF CUTTING PARAMETERS IN THE LEATHER SPLITTING PROCESS

G.E.Hank

*Rudolf Alber GmbH & Co. KG, Sales director 73061 Ebersbach, Germany,*

*g.hank@alber-tools.de*

**Abstract.** This article wants to combine two perspectives: First, Leather production with its diverse quality requirements and second, the new evolutions in the field of bandknife properties. In a short introduction the splitting process as such will be described, its different use in several stages and leather types, also in the field of leather conversion (in shoe, leathergoods and automotive parts production). Influencing factors of the possible goals like quality and cost efficiency will be discussed. In the second part some main requirements and problem fields of leather splitting are analyzed in more detail. Requirements such as thickness tolerance, tensile strength or fibre-free smooth cutting surface. Difficulties in practice like chrome nests, hard water, poor raw material, feeding speed, influence of abrasivity of leather. In a third part the physics of the cutting process as such are described. Explanation of basic terms as "cutting ability", "edge retention", "pull vs. press cut". Resulting from this we get important parameters that refer to the bandknife blade: e.g. steel characteristics (hardness, flexibility, grindability, microstructure at cutting point, geometry of knife bevels, weldability etc.). The possibilities in modern bandknife production will be shown as for example: CNC-sensor-based tolerance measurements, pre-sharpening, surface roughness variations. This is completed with a short view on the other components of the process like splitting machine (points like sharpness measuring), grinding stones (roughness-exactness controversy diagram). The fourth and last part puts the two perspectives together: Optimized bandknife characteristics for specific leather material. Alternative steel types that due to new properties allow to meet also new requirements.

## 1 Introduction

The author of this article works at Rudolf Alber GmbH & Co. KG Germany, a manufacturer of splitting bandknives for the leather industry. This article wants to combine two perspectives: First, the splitting process in leather production with its diverse quality requirements and second, the new evolutions in the field of bandknife properties. Through thorough analysis of the parameters that affect the performance of a splitting blade, optimum blade selection can be achieved. Issues like splitting machine set-up, grinding stones, etc. are peripheral to this essay and are, despite their importance for the whole process, not in focus this time.

## 2 Splitting leather

Splitting is often described as the "most complex" or "key process" for achieving a maximum utilization of the hide area in even thickness. Animal hides consist of a structure of three-dimensional fibers building a derma and a flesh layer of varying thickness, while for the final product (shoe, leathergoods, automotive component etc.) a constant thickness of leather is required.

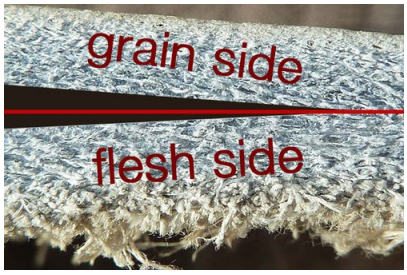



**Fig. 1.** Splitting leather.

Splitting can be done in different stages: Lime, tanned (Wet-Blue etc.) and dry leather. Additionally, for the production of shoes, leathergoods, automotive seat covers and components the converting industry splits the finished leather again into various thinner layers for its final use.

The physical separation of the grain and the flesh side happens by the process of feeding the hide through the splitting machine.

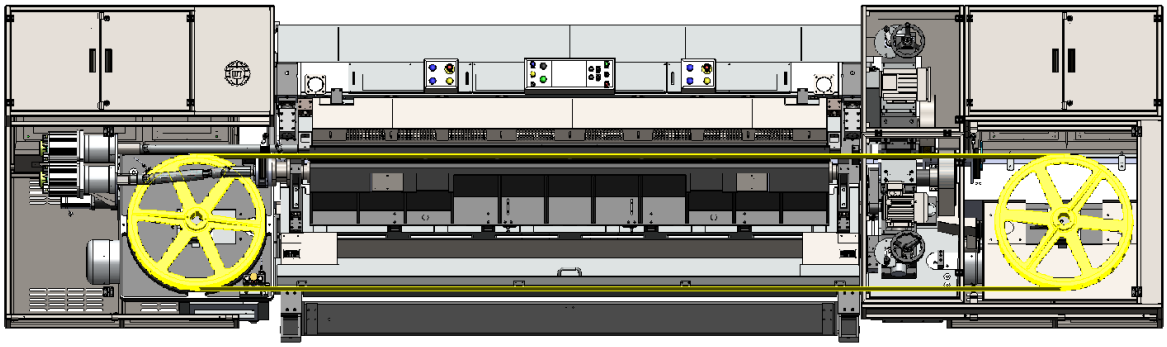


**Fig. 2.** Front-view of a splitting machine used in tanneries.

Splitting machines are complex systems of high-precision components that require for an optimum performance a bandknife with the following minimum characteristics:

- Thickness tolerance below 0,02mm as blade guides settings can be adjusted in practice with only a 0,03mm gap.
- Tracking, i.e. parallelity of blade with tolerances below 0,02mm.
- Possibility to work on different bevel lengths according to hide type.

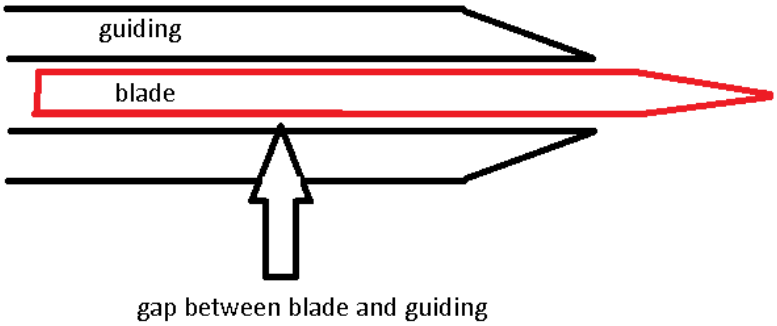



**Fig. 3.** Sketch of bandknife and machine guidings, also called jaw plates.

There are specific requirements and considerations according to the stage of splitting.

### 2.1 Lime splitting

The weight of the hide is basis for the needed volume of tanning agents. This means that splitting should remove as much of the flesh side as possible and leave as much of the grain side as needed. Splitting reduces the tensile strength of the hide, values for grain and flesh material depend on their

remaining thickness. Volume of chrome waste resulting from further steps in Wet-Blue tanning is reduced. As swelling has increased the thickness of hides, an exact splitting, and therefore a high precise bandknife, becomes even more important to achieve the intended final thickness range. Lime splitting allows the use of the split flesh side for products where untanned material is needed. Untanned material can be sold e.g. to the collagen industry, meat casing, cosmetics. Considering these points it is clear that the splitting process plays an important role for the overall economical view.

Hides in lime stage are softer than in wet-blue or dry stage, therefore easier to split, but dirt or lime nests built up from hard water might damage the fine edge. A steel with a higher shock-load-capacity keeps the edge longer. Up to 50.000 bovine hides can be split per blade in lime stage.

### 2.2 Wet-Blue

After tanning hides are having a stiffer fiber structure, swelling effect as in Lime is far less. Higher precision in splitting in this stage reduces efforts and cost done in the following shaving process. In case wet-blue split is sold, an optimization in surface outcome is reached by better splitting.

Humidity of hides has influence on hardness, abrasiveness of freshly tanned hides is lower than for transported and stored material. The edge of the blade needs more sharpening in the second case, life-time of blade is lower. The number of hides split per blade ranges between 5.000 – 40.000, depending also on the type of hides and tanning method. Often splitting is done by contractors outside the , for them the possible feeding speed directly influences the daily production potential. The impact of other tanning agents than chrome, like e.g. aluminium, on the bandknife is in many cases negative, as higher abrasiveness requires more intense resharpening.

### 2.3 Wet-White

Wet-White covers a wide field of chrome-free tanned or pre-tanned hides. Effects on splitting depend on whether synthetic contents leaves a more or less abrasive fibre structure. In the cases studied for this analysis the Wet-white material had a softer structure compared to similar hides in Wet-Blue. But splitting of this material is more difficult, especially when its humidity is low. In practice Wet-White finds often application in high quality end products, the need to reach necessary precision often leads to a higher grinding intensity for the blade, in order to even more clearly minimize rejections due to over or under thickness.

### 2.4 Dry leather

Dry leather is split in tanneries to reduce thickness further for Crust or finished leather. In some cases it is done to clean inner side from fibers and to reach a smooth surface. In the production of shoes, leathergoods, automotive leather etc., finished leather is split again according to the thickness needs of final products. This is done on smaller component splitting machines with working width of 300-800mm. Dry leather is a quite abrasive material, edge robustness becomes a decisive factor for the right steel selection for the bandknife. Errors in splitting can`t be cured by following processes.

## 3 Theory of splitting

„Splitting“ is a sub-category of „Cutting“ that divides one layer in two by moving a knife edge through hides horizontally. In comparison to a „Sawing“ process that is used to cut rigid material, the flexible hide opens it structures and therefore the knife does not need to destroy material (sawdust) but leaves both layers intact.

### 3.1 Cutting ability

In the following we want to have a deeper view of what happens at the cutting edge. While the knife enters the material two cutting forces work physically

- Draw cut
- Press cut

To better define the „cutting ability“ of a bandknife we have to see the following parameters

- Edge angle β
- Edge thickness d
- Sharpness b
- Theoretical sharpness b‘

Forces that work are

- Pressure
- Friction Fr

A wide edge angle increases the stiction, friction caused by material sticking on the surface.

- Speed i.e. Velocity Vz of bandknife turning on machine

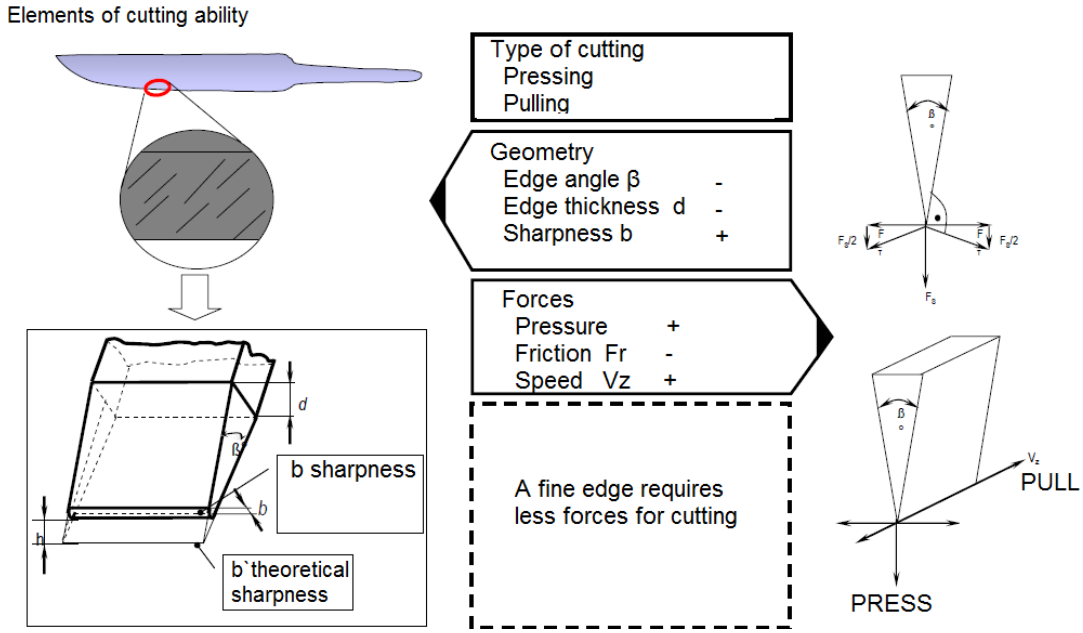



**Fig. 4.** Elements of cutting ability[1].

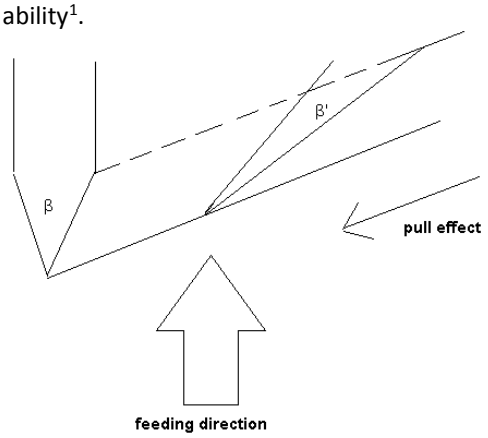



**Fig. 5.** Edge angle with pull-effect.

[1] *Adapted from Landes (2003)*

With the movement of the blade the edge angle β turns into thinner cutting angle β'. A thin edge angle with high sharpness has the best cutting ability, for leather splitting this means a precise cut, fibres are cut and not torn, result is smooth fibre-free cutting surface.

### 3.2 Edge robustness

Before coming back to the cutting ability, we have to take a look at the „Edge Robustness". A thin razor blade has a high cutting ability, but is weak, a wood axe is robust but due to its thick edge only able to cut with heavy forces. For leather splitting we need to combine both characteristics - ability and robustness - as cutting precision is important and volume to be cut is quite high. e.g. up to 50.000 hides with one blade. The edge robustness depends on Edge angle, Material (steel type), Hardening of steel, Infrastructure (machine, grinding system etc.).

#### *3.2.1 Edge robustness und edge angle*

Steel has carbide grains that differ with the content of alloy elements. We can distinguish fine and rough grains. With a fine carbide structure a narrow edge is possible. This narrow edge at the same time has a higher edge robustness.

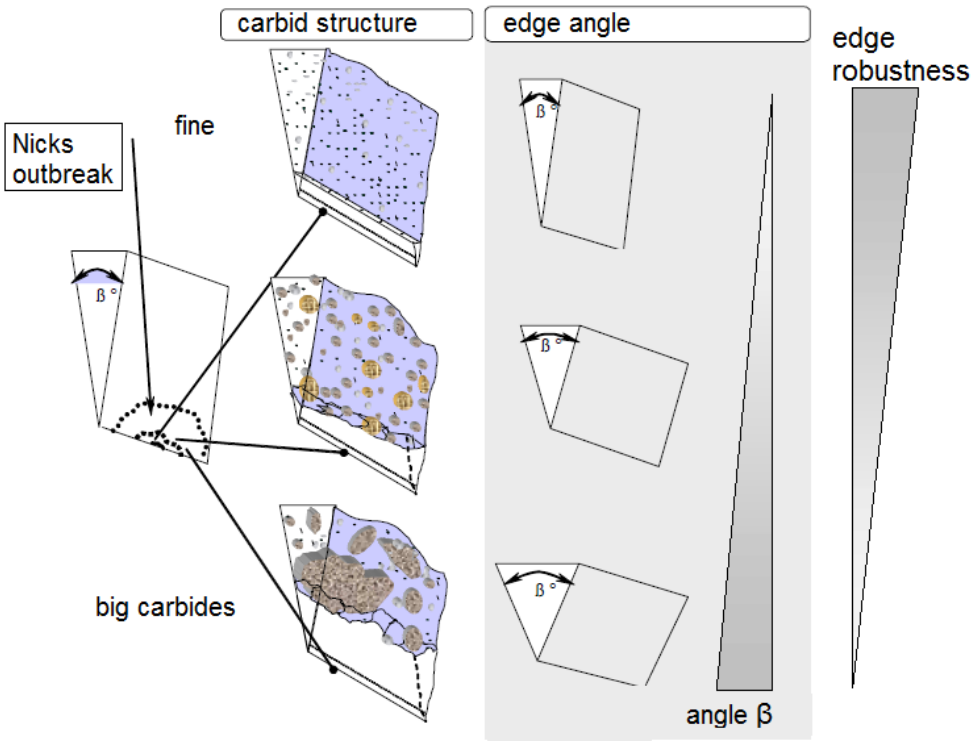



**Fig. 6.** Bevel robustness[2].

The bevel robustness decreases by increasing the edge angle β. Steel particles break out of the edge due to the friction against the hides to be split. This means the harder the material to be cut, the shorter should be the bevels. In tanneries splitting machines usually use inner bevels (flesh side) shorter than the outer bevels (grain side), this is reached by different size of grinding wheels or same size of grinding wheels but different position. In tanneries the following bevels in mm are in use.

[2] *Adapted from Landes (2003)*

**Table 1.** edge geometry according to process step in tanneries.

| | inner bevel | outer bevel |
|---|---|---|
| Lime | 3,7-4,0 | 5,5-6,0 |
| Wet-Blue | 3,2-3,7 | 5,0-5,5 |
| Crust/Dry | 2,5-3,5 | 4,0-5,0 |

***3.2.2 Sharpening***

On modern splitting machines ceramic disc grinding stones are used. The harder the steel, the softer the grinding stone should be. Hardness for grinding stones used in leather splitters ranges from soft to medium, described in alphabet letters like H, I, J. The grain of the stones break during use, resharpen themselves and finally get lost.

Porosity is needed to avoid overheating. Softer steels tend to paste the porosity of the grinding stones that have to be dressed then more often. Besides the parameters hardness and material of grinding stones, the main variable is the grain level. Stones which are used for leather range from rough grain at 36, middle is 46, fine 60 or 80.

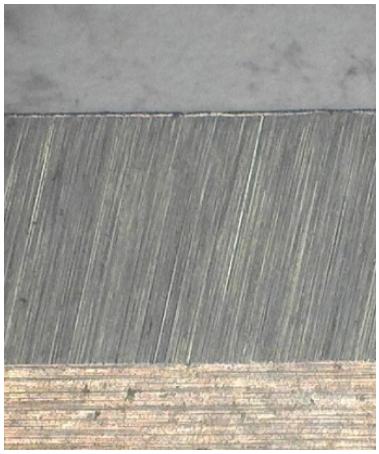


**Fig. 7.** Picture of a bevel profile sharpened with grain 46, edge not yet 100% sharpened.

A fine grain creates a finer blade edge, notches are avoided. This increases life-time of the bandknife. Working in an environment where the edge gets easily blunt, due to harder material to be split, in practice a more aggressive grinding stone with rough grain can be the better choice when focus is on speed of production and resharpening time means unused production time. [3]

[3] *The author knows the discussion about alleged advantages of a micro-toothing caused by rough grinding wheels. However, this micro-toothing has the disadvantage of a minor theoretical sharpness.*

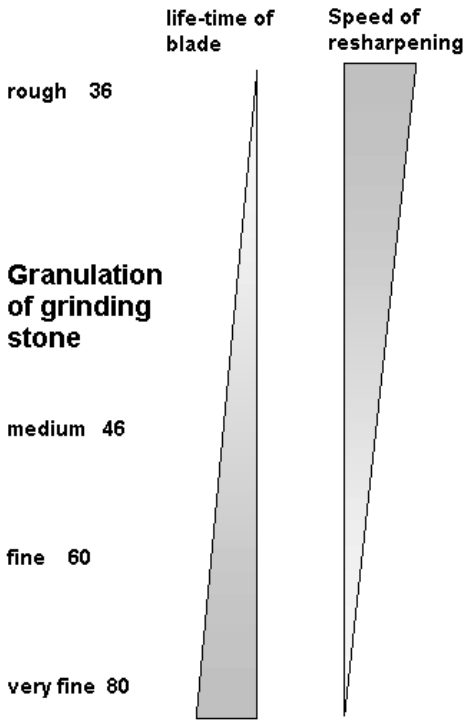



**Fig. 8.** Trade-off between speed of sharpening and life-time of blade.

The intensity of sharpening defines the life-time of the bandknife. In modern splitting machines an automatic level of sharpening can be programmed. Measuring the degree of sharpness as input signal for this automatism is a prerequisite for further optimization.

## 4 Steel type

Steel is an alloy of iron and carbon, by including other elements like chromium, manganese, nickel, etc. the characteristics can be influenced.

Due to the special machine set-up for splitting with two wheels, a turning bandknife is used. (compared to other types, e.g. fix static knives, cylindrical shaving knives, oscillating knives etc.) The steel has to comply additionally with characteristics such as

- Flexibility : machine wheels have diameter of 30-100cm , means band has to bend and then come back to a linear cutting line. The bending gives an upper limit to the hardness of steel.
- Weldability: Bandknives are „endlessly welded“, to avoid irregular cutting, welding joint has to be homogeneous with rest of the band.
- Availability and cost efficiency: Steel for splitting bandknives has to be available in constant quality and reasonable cost. By Intense sharpening the blade is “consumed” and needs to be substituted after its life-time.

### 4.1 Flexibility vs. Hardness - tensile strength of steel

While flexibility is a minimum requirement defined by the bending angle of the fly-wheels of the machine, Hardness is a maximum aim to be reached. A C75 steel, used for splitter blades has a yield point at around Rp = 1300N/mm². Elasticity-modul at 210 Gigapascal. Important that also the welding joint has a similar level. The needed elasticity is in conflict with the aim to increase tensile

strength for better edge resistance. In other words: For bandknives the need to stay flexible puts a limit to positive influence of higher steel hardness. As maximum hardness drops out as the sole variable, the steel composition becomes the decisive factor for edge resistance and optimum cutting ability.

### 4.2 Cutting quality

The combination of cutting ability and edge robustness over the time give the total result as „Cutting quality".

The „edge robustness" might be better for blades made out of materials like ceramic or hard-metal coated edges.

### 4.3 Carbon content

In the production of steel, Carbon content is the main parameter. A content of 0,8%C is the line where below there is still α –Ferrite included, above not. For higher carbon content the free carbon allows higher hardening of steel as in molecular scaffold interruptions to the Fe-structure are possible. At the same time, more grain boundary cementite builds up at the grain limits, this leads to a possibly harder but more brittle structure.

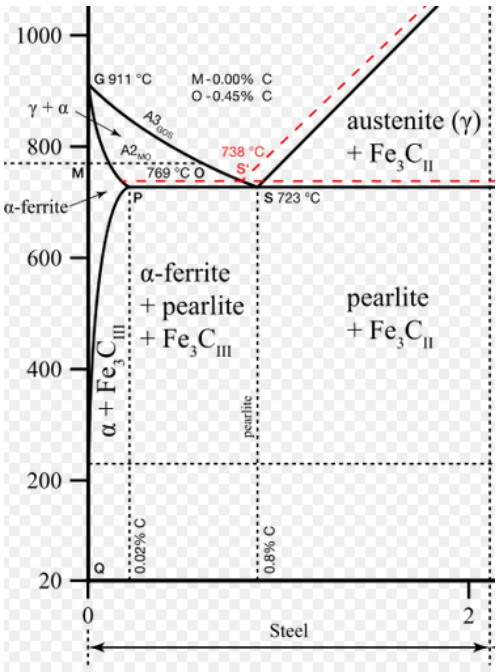



**Fig. 9.** Detail of the Fe-C equilibrium phase diagram.

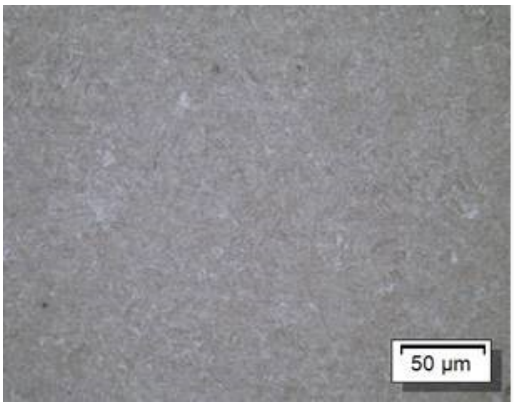
The building up of a different grain structure needed for higher hardness also can be achieved with other elements than Carbon, avoiding this effect of higher brittleness, like e.g. Chrome 4. The steel options for splitting bandknives are limited by the above mentioned requirements. Most manufacturers use a simple C75 spring steel, available as a side-product from the much bigger market for bandsaws. We will compare in the following four steel types C75, C75CR1, C100, and SY5.

[4] *It is by coincidence that Chrome plays already an important role in the tanning industry.*

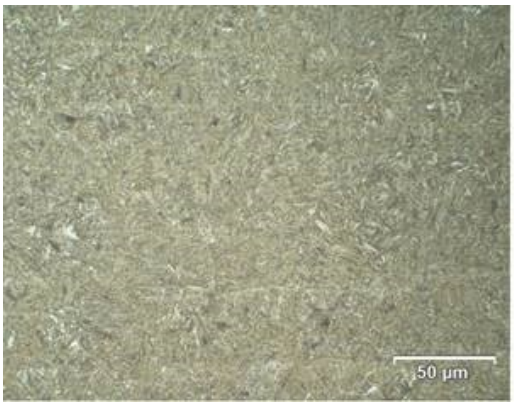
[5] *(SY is a non official norm description, used for reasons of protection against competitors by the author).*

**Microscopic structure**

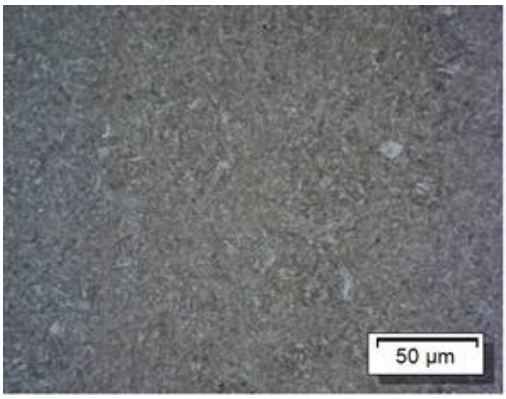
C75



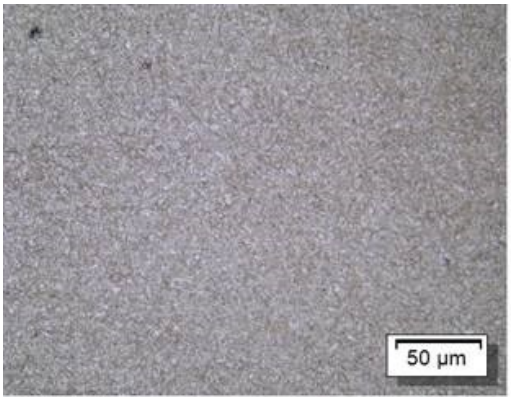

C75CR1




C100




Alber SY



C75 and Alber SY show a fine homogeneous structure, for the C75CR1 and C100 the expected grains are visible.[6] The following diagram illustrates edge-resistance vs. ability for hardening as regards the four steel types:

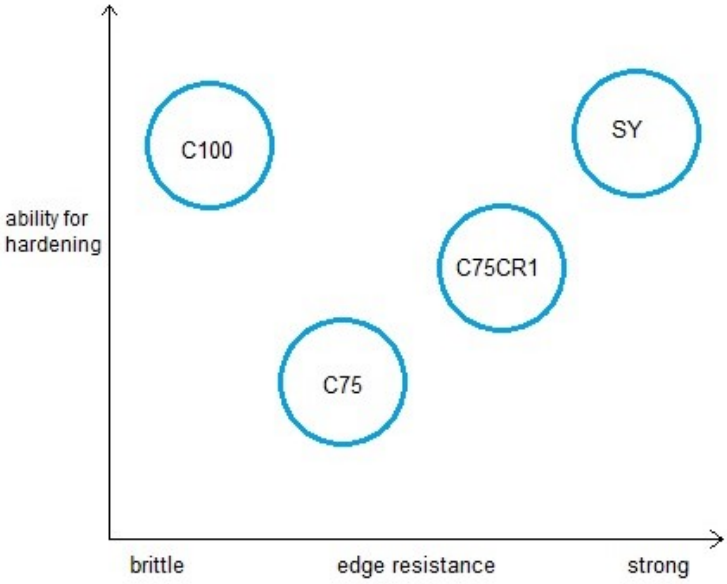



**Fig. 10.** Edge-resistance vs. ability for hardening.

## 5 Modern bandknife production

Having chosen the optimum steel, the manufacturer of bandknives has to source this steel and convert it to a perfect tool.

Steel production is a two-step process. In the steel mill the composition of the final steel is defined by preparing the melt. In a second step the cold–rolling defines dimension and hardness of the coil that is the base for further processes. In bandknife production the steps are then

- Initial quality control
- Cutting to length
- Welding
- Rectification of surface – correct thickness
- Bevelling and back preparation – correct tracking
- Final quality control and packing

### 5.1 Cutting to length

The length of a bandknife is determined by the splitting machine. As for other machines in leather production working width range of 1500mm, 2300mm, 2700mm, 3000mm, 3200mm and 3400mm are standard. The blade is kept on the machine by a system tensioning the blade with the two wheels. The tensioning of the splitting machine compensates the possible expansion of thermal expansion, with a coefficient for steel of 0,0115 and a blade length of for example 10meters, the expansion for a 20 degree temperature increase comes to 2,3mm. These parameters determine the length value and the allowed tolerance range.

[6] The structure visible in the microscopic structure of the steel is not only a result of the steel composition, but also of the different processes like hardening and rolling.

### 5.2 Welding

Welding is done with butt-welding machines. No additional weld elements are added. Pressure, electrical impulse and temperature curve are programmable for each different steel type. The target is to reach same level of tensile strength in welding zone as in the rest of the band. Optimum glowing temperature can vary for different steel types.

**Fig. 11.** Welding machine.

### 5.3 Rectification – correct thickness

As said in the beginning, a bandknife is an endlessly welded band, that should be homogeneous and constant in order to guarantee a smooth surface. Before rectification a welded raw steel band has a thickness tolerance of approx. 0,5mm, mainly caused by the welding point. This high irregularity would leave grooves and marks on the hides. The aim is to minimize the thickness tolerance of the blade. Tolerances of less than 0,02mm in thickness and tracking have to be guaranteed by CNC-machines with its non-touching sensors. This is necessary to allow the band to run between the blade guiding which gap is set down to 0,03mm.

One of the main reasons for poor performance of the splitting process is the wrong adjustment of machine components or a use of a bandknife that is not fulfilling the required tolerances.[7] Surface roughness of the blade is the result of the rectification process. Standard value for roughness is between 0,8 and 0,95. A blade surface that is too rough may damage the blade guidings and leads to a reduced overall performance in medium term.

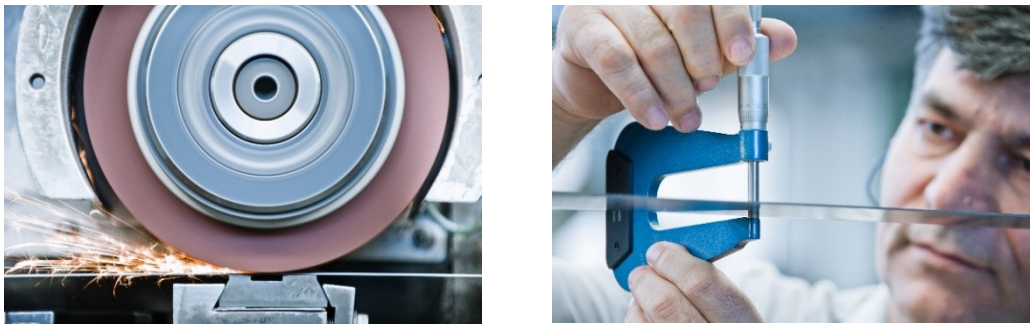


**Fig. 12.** Rectification grinding stone and manual final thickness control after rectification.

### 5.4 Bevelling and blade back preparation – correct tracking

After having prepared the exact thickness, bandknives are pre-bevelled. Parallel tracking of blades with tolerance below 0,02mm has to be guaranteed in order to avoid side-movement of blade inside machine.

[7] *Brochure of problem solving for wrong splitting performance available with the author*

Arriving at the tannery, the bandknife is already pre-bevelled – the final 100% sharpening is done on the splitting machine. A well-done pre-bevelling saves time when mounting the blade. Asymmetrical bevels can be done for pre-bevelling to save even further minutes and reduce down-time of machine. For quality control systems at end-user, blades can be identified with serial number and protocol of precision values.

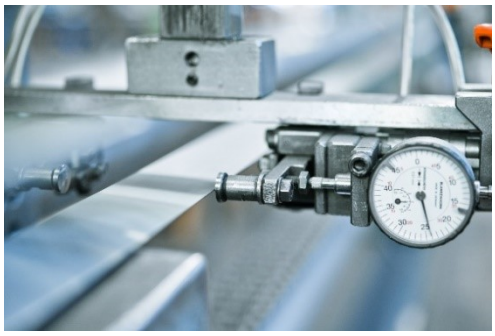


**Fig. 13.** Tracking sensors able to measure tightest tolerances.

## 6 Final conclusion and optimum steel selection

The bandknife is a small but important component in the whole production process of leather products. For the steel selection several parameters have to be considered that limit in practice the available choices. To our comparison we add parameters:

- sharpening ability
- welding ability
- shock load capacity

We come to the following more complete comparison:

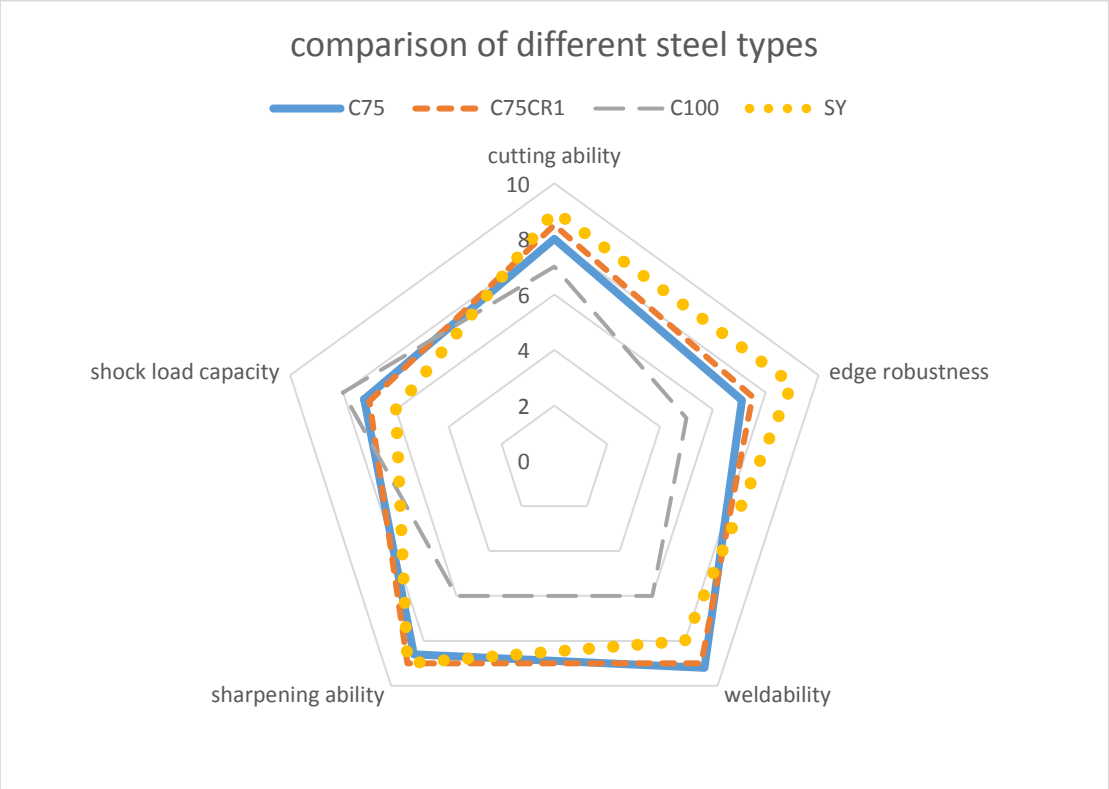



**Fig. 14** Steel evaluation of different characteristics

An optimum steel selection, based on the above-discussed arguments looks as follows:

**Table 2.** Steel recommendation.

| sector | Leather type | Steel Recommendation | |
|---|---|---|---|
| | | Standard | increased performance |
| Tannery | Lime | C75, 48 HRC | C75CR1, 48 HRC |
| | Wet-Blue | C75, 48 HRC | C75CR1, 48 HRC, SY 49HRC |
| | Wet-White | C75CR1, 48HRC | SY, 49 HRC |
| | Crust | C75CR1, 48HRC | SY, 49 HRC |
| | Dry | C75CR1, 48HRC | SY, 49 HRC |
| | Dry automotive | C75CR1, 48HRC | SY, 49 HRC |
| Converting industry | finished leather | C75, 52 HRC | SY, 53 HRC |
| | finished leather automotive | C75, 52 HRC | SY, 53 HRC |

Whether the technical benefits of better performance can be realized in practice depend on further conditions as described under topics 2 and 3. Commercial aspects, steel cost and availability, contribute to the overall result. Material science is a wide field evolving further, this is valid both for leather as for steel. We invite you to accompany us in the search for optimization of the splitting process.

## References


1. *Burmester, Jürgen et.al. (2017), Fachkunde Metall, Josef Dillinger, Walter Escherich, Eckhard Ignatowitz, Stefan Oesterle, Ludwig Reißler, Andreas Stephan, Reinhard Vetter, Falko Wieneke, Europa-Lehrmittel, Haan, Germany*
2. *Chambon, Romain, Sales director at MERCIER TURNER Annonay, France*
3. *La spaccatrice, Quaderni di ingegneria conciaria, Quaderno 5, Assomac, Vigevano, Italy, w/o year*
4. *Landes, Roman (2003): Messerklingen und Stahl, Wieland Verlag, Bad Aibling, Germany*
5. *Moog, Gerhard E. (2005): Der Gerber, Eugen Ulmer KG, Stuttgart Germany*