Improvement of quality indices of leather fabrics of fur skins

Gayrat Bahadirov[1], Ayder Nabiev[1*], and Gerasim Tsoy[1]

[1]Institute of Mechanics and Seismic Stability of Structures named after M.T.Urazbaev, Uzbekistan Academy of Sciences, Department of Theory of Mechanisms and Machines, Tashkent, 100125, Uzbekistan

Abstract . The article is devoted to research on improving the quality indices and elastic-plastic properties of leather fabric of fur skins. An improved method and operative parts were developed that help ensure high elastic-plastic properties of leather fabric of fur skins after mechanical processing. The design and geometric parameters of the operative parts of the improved design were studied and analyzed. It was determined that when using the recommended operative parts, the required quality of leather fabric of fur skins is achieved by increasing the contact points between the operative parts and the processed material. Keywords leather fabric, fur raw materials, staking process, quality of raw materials, operative parts.

1 Introduction

The main group properties inherent in semi-finished leather and fur products and manifested in their use include functionality, reliability in wear, ergonomics, aesthetics, and manufacturability. Let us consider well-known studies and publications devoted to improving the quality of fur raw materials.

Article [1] describes the geometry of the shape of trimming knives and the geometry of their sharpening for single-jaw harvester heads. The main reasons for geometry violations during operation, which affect the quality of trimming, were identified.

Reference [2] studies the durability of paper-cutting machine knives during operation. The physical phenomena when cutting a stack of paper and the main factors that determine the wear of knives during the operation of paper-cutting machines are considered. The results of experimental studies of knife wear for specific paper-cutting conditions are presented. A mathematical model is proposed to describe the wear process of knives.

In [3], based on the developed methodology, the energy consumption when a cantilever knife penetrates soil was calculated; to overcome the pressure of soil on the front chamfer of the cantilever knife, to lift the soil, under vertical acceleration of soil by the front chamfer, to overcome the friction of soil with the front chamfer and the lower plane of the cantilever knife. The total energy costs and their structure during the interaction of a cantilever knife with soil with a volume of one cubic meter were determined. The horizontal longitudinal force required to move the cantilever knife was determined.

* Corresponding author: a.nabiev@mail.ru

In [4], the influence of skin and fur processing using new technologies on the formation of corium volume was studied using model systems and under production conditions. It was shown that treatment in a mixture of hydrophobic and hydrophilic solvents reduces the internal tension of the skin that occurs during drying and improves the formation of corium volume. New technologies for leather and fur based on the use of dispersed systems during tanning can reduce skin shrinkage area by 10%, increase the strength of leather by 20%, and sheepskin fir by 14%.

The study in [5] examines the problems of skin and fur as a nutrient medium for the development of microorganisms. The authors pay attention to ways to protect skin and fur from the impact of microorganisms.

The authors of [6] developed an empirical method for predicting changes in the microstructure of tanned corium and natural hair depending on the initial state of the microstructure and the parameters of HF plasma modification. Based on the structural prediction technique, recommendations were developed for the industrial use of HF plasma modification in the production of a wide range of leather and fur products.

In [7], the issues of reducing defects in the structure of the skin using HF plasma modification in the technological cycle of tanning production were considered. Plasma processing modes for raw materials and semi-finished products were determined to reduce the manifestation of hardness and friability defects.

Reference [8] examines the impact of non-equilibrium low-temperature plasma modification on the operational, consumer, and aesthetic properties of leather materials at the pretanning and tanning stages of the technical process. It was established that due to non-equilibrium low-temperature plasma modification, it is possible to change the structure and morphology of leather materials, improving aesthetic, consumer, and operational properties and increasing atmospheric-biocorrosion resistance.

The author of [9] analyzed the influence of high-frequency capacitive plasma treatment on changes in the physical and mechanical characteristics of polypropylene fiber samples.

The properties of leather were studied theoretically [10–14] and experimentally [15–19], and machines and devices were developed to improve the quality of mechanical processing of leather and fur raw materials.

2 Material and method of research

Previously, we have developed knives for a staking machine with wavy blades, subsequently assembled and fixed in the grooves of the working drum. Figure 1 shows a scheme of a knife in a staking machine with three waves and one-sided sharpening of working blades.

As shown in Figs. 1 and 2, knives of the staking machine can be made with three or two waves on their working blades. Then, on the working drum, these knives are alternatively fixed in grooves. The number of knives is 10 pcs; therefore, it is necessary to produce 5 knives of each option.

The knives with wave-shaped blades can be used on a staking machine in combination with serial knives (not shown in the figure).

Our goal is to increase the mechanical effect on the leather fabric of processed fur skins using knives with wave-shaped blades.

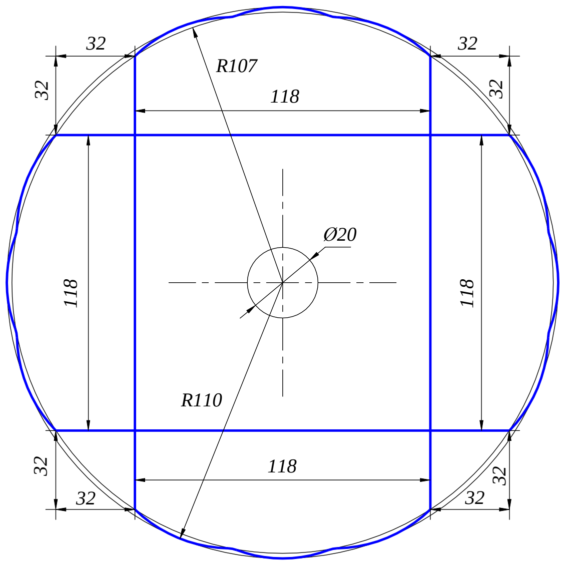

Fig. 1. Scheme for manufacturing knives with three waves on the blade.

Figure 2 shows a similar scheme for manufacturing knives with two waves on the working blades.

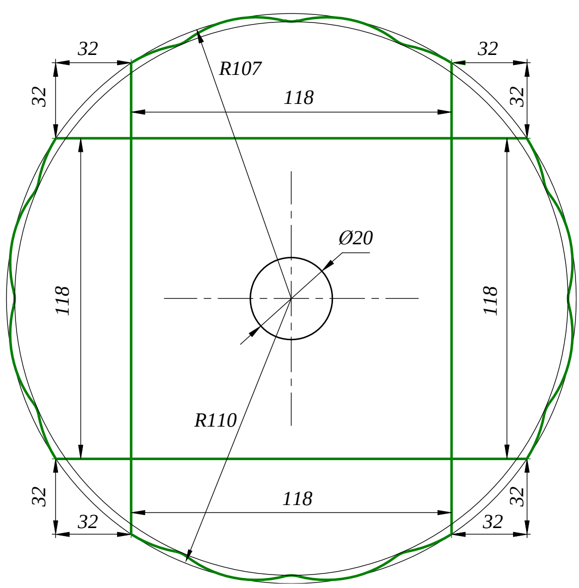

Fig. 2. Scheme for manufacturing knives with three waves on the blade.

Next, we present a detailed sequence of manufacturing (metal) knives with wavy blades [20–23].

1. A template for the contour of the knife blade line is pre-made.
2. The material used for the knives is carbon tool steel U8 or other.
3. Three sheets of material are taken and templates with three waves are installed on the first sheet, and templates with two waves are installed on the second sheet, and a contour is cut out on a laser cutting machine, and a hole with a diameter of 20 mm is cut out in each sheet in the center of the circle.

4. On a milling machine, a 3mm wide chamfer is made along the outer circumference at an angle of 35 degrees to the surface of the sheet material.

5. On a grinding machine, the chamfer of the sheet contour is ground and polished.

6. Knives are cut from the sheet on a laser machine in a straight line along the blue and green lines according to the drawings in Figures 1, 2.

7. When the knife blade wears out, it is removed from the operative part of the drum and sharpened according to the following scheme.

A knife template is applied equidistant to the initial position of the knife blade contour along its two basic supports (along the sideline and the bottom line of the knife perpendicular to it) and then it is secured. The knife blade is then sharpened to the new contour using a template [24–27].

Below we give an example of the planned sharpening of knives with a wavy blade.

Next, to determine the schemes of manufacturing and further sharpening of knives with wavy blades, we proceed to calculate the contour trajectory for each option of knives [28-30].

Let us draw up a calculation scheme to determine the trajectory of the curved line of the operative part of the knife of the staking machine (Fig. 5).

Below we will give an example for the implementation of planned sharpening of knives with a wave-shaped blade. The diagram of the device for single-sided sharpening of the knife blade is shown in Figures 3 and 4. The device consists of a knife 1, a template 2, a guide 3, a bed 4, a cutter or an emery wheel 5, an axis 6, a rotating roller 7, a nut 8, a bolt 9 and nuts 10,11. Templates 2 can be made of a metal plate with a curvilinear line of the knife is fixed with a knife 1 bolt 9 and nuts 10, 11. An axis 6 with a milling cutter or an emery wheel 5 is attached to the chuck of the drilling or vertical milling machine. The knife 1 with the template 2 is brought to the roller 7 and the milling cutter or an emery wheel 5. The rotating roller 7 is the base stop for the curved line of the knife 1. The second base stop is the side surface of the roller 7 for the lower surface of the knife 1.

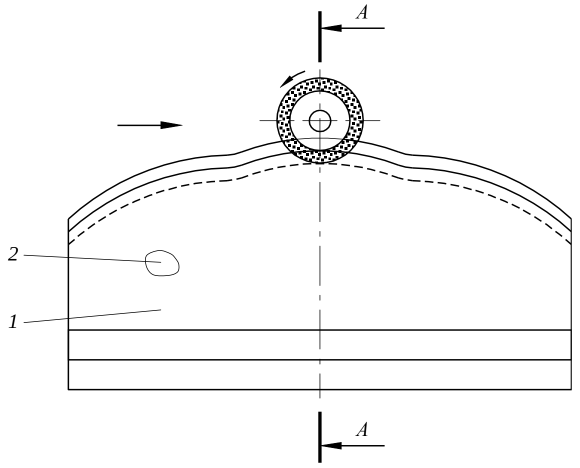

Fig. 3. Scheme for single-sided sharpening of knives with a wave-shaped blade

Next, to determine the schemes of manufacturing and further sharpening of knives with wavy blades, we proceed to calculate the contour trajectory for each option of knives [31-33].

 https://doi.org/10.1051/bioconf/202413007015

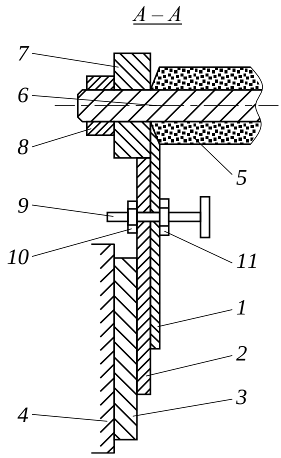

Fig. 4. Scheme of a device for single-sided sharpening of knives

The sharpening device operates as follows. Knife 1 with template 2 is brought to roller 7. Then the electric motor is turned on to rotate the cutter or grinding wheel 5 until contact is made. Sharpening begins from one end, moving the knife with the template so that the template does not come off the roller, copying the topography of the knife line. Similarly, after each blunting of the knife blade, sharpening is carried out in a similar way. In this case, the contour of the blunted knife blade 1 is first restored on a laser machine, also using a copier or using an electronic program compiled earlier. A copier can also be used to sharpen two-wave knife blades. Sharpening of knives is carried out periodically after processing 10–20 depending on the size of fur skins (rabbit, otter and other small fur animals).

Let us draw up a calculation scheme to determine the trajectory of the curved line of the operative part of the knife of the staking machine (Fig. 5).

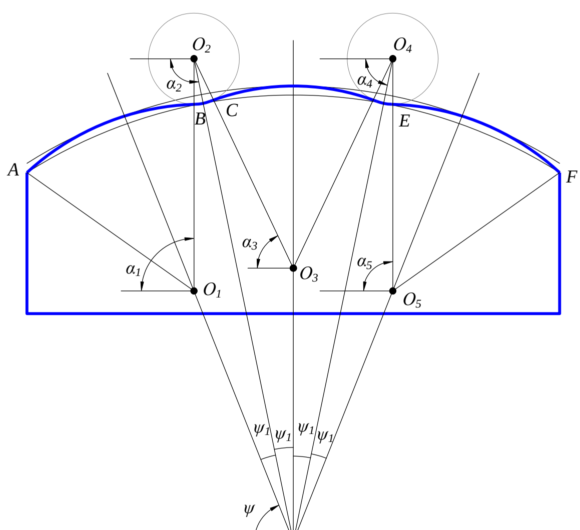

Fig. 5. Calculation diagram of the contour of the working edge of a knife with three waves on the blade

Based on Fig. 5, we will derive an equation for the trajectory of the curved line of the working edge of the knife, formed from point A to point F. To do this, we successively divide the curved line connecting points A and F into segments.

To begin with, we continue arc AB and form a circle with radius r1, the center of this circle will be at point O_1. To describe arc AB of this circle, we can derive an equation of motion relative to the coordinate axes:

$$\begin{aligned} x_1 &= OO_1\cos\psi - r_1\cos\alpha_1 \\ y_1 &= OO_1\sin\psi + r_1\sin\alpha_1 \end{aligned} \tag{1}$$

here, OO_1 is the distance from the origin of the fixed coordinate system to the center of the circle formed by arc AB; ψ is the angle formed between the abscissa axis of the fixed coordinate system and the distance from the origin of the fixed coordinate to the center of the circle formed by arc AB, where arc AB is a constant value; α_1 is the angle formed by the abscissa axis of a point moving along arc AB.

Let us solve the system of equations (1) with respect to variable α_1:

$$\begin{aligned} r_1\cos\alpha_1 &= OO_1\cos\psi - x_1 \\ r_1\sin\alpha_1 &= OO_1\sin\psi + y_1 \end{aligned} \tag{2}$$

Adding the squares of the powers of each equation of the system of equations (2), we write the following expression:

$$r_1^2 = \left(OO_1\cos\psi - x_1\right)^2 + \left(OO_1\sin\psi + y_1\right)^2 \ ;$$

$$\begin{aligned} r_1^2 &= OO_1^2\cos^2\psi + x_1^2 - 2OO_1\cos\psi x_1 + \\ &+ OO_1^2\sin^2\psi + y_1^2 - 2OO_1\sin\psi y_1 = \\ &= OO_1^2 + x_1^2 + y_1^2 - 2OO_1\left(y_1\sin\psi + x_1\cos\psi\right). \end{aligned} \tag{3}$$

Eq. (3) is the equation of motion of arc AB.

We move on to the next arc BC in Fig. 5. Continuing the ends of arc BC, we form a circle with a center at point O_2 and radius r_2. According to the resulting scheme in Fig. 5, we can derive the following equation:

$$\begin{aligned} x_2 &= -OO_2\cos(\psi + \psi_1) - r_2\cos\alpha_2 \\ y_2 &= OO_2\sin(\psi + \psi_1) - r_2\sin\alpha_2 \end{aligned} \tag{4}$$

here, OO_2 is the distance from the origin of the fixed coordinate system to the center of the circle formed by arc BC; $\psi+\psi_1$ is the angle formed between the abscissa axis of the fixed coordinate system and the distance from the origin of the fixed coordinate system to the center of the circle formed by arc BC, where arc BC is a constant value; α_2 is the angle formed by the abscissa axis of a point moving along arc BC.

Let us write the system of equations (4) in the following form:

$$\begin{aligned} r_2\cos\alpha_2 &= -OO_2\cos(\psi + \psi_1) - x_2 \\ r_2\sin\alpha_2 &= OO_2\sin(\psi + \psi_1) - y_2 \end{aligned} \tag{5}$$

Let us raise each equation of system (5) to a square power and add these equations:

$$\begin{aligned} & r_2^2\sin^2\alpha_2 + r_2^2\cos^2\alpha_2 = \left(OO_2\sin(\psi + \psi_1) - y_2\right)^2 - \\ & - \left(OO_2\cos(\psi + \psi_1) + x_2\right)^2; \end{aligned}$$

$$\begin{aligned} & r_2^2\sin^2\alpha_2 + r_2^2\cos^2\alpha_2 = -OO_2^2\cos^2(\psi + \psi_1) - \\ & - x_2^2 + OO_2^2\sin^2(\psi + \psi_1) - y_2^2 - \\ & - 2OO_2\sin(\psi + \psi_1)y_2 - 2OO_2\cos(\psi + \psi_1)x_2. \end{aligned} \tag{6}$$

as a result, we obtain a relation expressing the equation of motion (6) along arc BC.

3 Results

From equations (3), (6) obtained above, it is clear that the radii of each of the curves forming the blade with ends at points A and F, forming parts of the circle r_1, r_2 are. The equation of this trajectory is the change in the angle formed between the abscissa axis of the fixed coordinate system and the distance from the origin of the fixed coordinates to the center of the circle formed by arcs; from the origin of the fixed coordinate system along the arc line and depends on the change in the distance to the center of the circle formed.

Using the resulting equation for the trajectory of a curved line covering the working blade of the staking knife, we can automate the process of manufacturing and sharpening a knife with wavy blades.

References

1. A.A. Seliverstov, I.V. Simonova, A.A. Aleksandrov, Study of the state of geometry of the shape and sharpening of harvester trimming knives, Resour. Technol. (2010)
2. M.I. Kulak, I.V. Marchenko, T.A. Dolgova, Proceedings of BSTU. Series 4: Print and media technologies **8(164)** (2013)
3. V.A. Nikolaiev, The Russian Automobile and Highway Industry Journal **17(3):** 340-350. (2020) https://doi.org/10.26518/2071-7296-2020-17-3-340-350
4. V.D. Radnaeva, N.V. Sovetkin, Bulletin of the Kazan Technological University **18** (2016)
5. E.L. Pekhtasheva, A.N. Neverov, G.E. Zaikov, S.Yu. Sofina, O.V. Stoyanov, Bulletin of the Kazan Technological University **7** (2012)
6. I.Sh. Abdullin, E.F. Voznesensky, L.V. Krasina, E.O. Kormakova, Bulletin of the Kazan Technological University **1** (2013)
7. G.N. Kulevtsov, E.F. Voznesensky, I.Sh. Abdullin, Bulletin of the Kazan Technological University **11** (2010)
8. E.I. Mekeshkina-Abdullina, G.N. Kulevtsov, Bulletin of the Kazan Technological University **3** (2013)
9. S.V. Ilyushina, Bulletin of the Kazan Technological University **17** (2013)
10. A.T. Amanov, G.A. Bahadirov, T.Y. Amanov, G.N. Tsoy, A.M. Nabiev, Journal Materials **12**, 21, (2019). Basel, Switzerland. https://doi.org/10.3390/ma12213620
11. A.T. Amanov, G.A. Bahadirov, T.Y. Amanov, G.N. Tsoy, A.M. Nabiev, International Journal on Advanced Science, Engineering and Information Technology **13**: 1, 321-328 (2023) DOI:10.18517/ijaseit.13.1.17360
12. A.T. Amanov, G.A. Bahadirov, A.M. Nabiev, A Study on the Pressure Mechanism Improvement of a Roller-Type Machine Working Bodies Materials (Basel). 2023
13. A.T. Amanov, G.A. Bahadirov, G.N. Tsoy, A.M. Nabiev, Improvement of the Process of Mechanical Dehydration of Five-Layer Semi-finished Wet Leather Products Text. Leather Rev (2021)
14. A.T. Amanov, G.A. Bahadirov, G.N. Tsoy, A.M. Nabiev, Effect of Multilayer Processing of Semi-finished Leather Products, Int. J. Mech. Eng. Robot. Res. (2022)
15. G. Bahadirov, M. Musirov, A. Nabiev, Eastern-European Journal of Enterprise Technologies **2(1(122).** 62–72 (2023). https://doi.org/10.15587/1729-4061.2023.277393

16. G.A.Bahadirov, A.A.Umarov, A.M.Nabiev, G.N.Tsoy, E3S Web of Conf. Volume **389** (2023) Ural Environmental Science Forum “Sustainable Development of Industrial Region” (UESF-2023). https://doi.org/10.1051/e3sconf/202338901028
17. G.A.Bahadirov, G.N.Tsoy, A.M.Nabiev, E3S Web of Conf. Volume **402** (2023). International Scientific Siberian Transport Forum - TransSiberia 2023. https://doi.org/10.1051/e3sconf/202340210016
18. T.Y.Amanov, S.D.Baubekov, G.N.Tsoy, A.M.Nabiev, Mod-High-Tech Technol. **9** (2018)
19. A.M.Nabiev, Combined extraction of liquid from wet leather semi-finished products, 7th International Conference on Industrial Engineering. Lecture Notes in Mechanical Engineering. Springer, Cham (2022) doi:org/10.1007/978-3-030-85233-7_59
20. G.N.Tsoy, Experimental determination of the influence of fibrous material on the dehydration of wet semi finished leather product. Proceedings of the 7th International Conference on Industrial Engineering (ICIE 2021). Lecture Notes in Mechanical Engineering. Springer, Cham (2022) https://doi.org/10.1007/978-3-030-85233-7_60
21. G.Bahadirov, G.Tsoy, A.Nabiev, EUREKA: Physics and Engineering, **(1)**, 86-96 (2022). https://doi.org/10.21303/2461-4262.2021.001606
22. A.T.Amanov, G.A.Bahadirov, G.N.Tsoy, A.M.Nabiev, International Journal of Mechanical Engineering and Robotics Research **10**, 3, 151-156 (2021) DOI: 10.18178/ijmerr.10.3.151-156
23. G.Bahadirov, T.Sultanov, G.Tsoy, A.Nabiev, E3S Web of Conferences **264**, id.04060 (2021) DOI: 10.1051/e3sconf/20212640406
24. A.M.Nabiev, G.N.Tsoy, G.A.Bahadirov, E3S Web of Conf. **376** (2023) (ERSME-2023). https://doi.org/10.1051/e3sconf/202337601073
25. A.Umarov, A.Nabiev, K.Khusanov, A.Shernaev, AIP Conf. Proc. **2821 (1):** 030020 (2021) https://doi.org/10.1063/5.0159452
26. A.M.Nabiev, G.N.Tsoy, G.A.Bahadirov, E3S Web of Conf. Volume **458** (2023); (EMMFT-2023) https://doi.org/10.1051/e3sconf/202345802015
27. A.M.Nabiev, G.N.Tsoy, G.A.Bahadirov, International Journal of Modern Manufacturing Technologies **XV**, 3 (2023) https://doi.org/10.54684/ijmmt.2023.15.3.8
28. G.A.Bahadirov, G.N.Tsoy, A.M.Nabiev, Equipment and technology for processing raw hides: Monograph (Novosibirsk: Publishing house LLC "SibAK". 2023)
29. G.A.Bahadirov, A.M.Nabiev, F.R.Rakhimov, M.U.Musirov, Izvestiya Vysshikh Uchebnykh Zavedenii, Seriya Teknologiya Tekstil'noi Promyshlennosti, **5(407)** 168-174 (2023)
30. A.M.Nabiev, G.N.Tsoy, G.A.Bahadirov, A.A.Umarov, F.R.Rakhimov, M.U.Musirov, BIO Web Conf. **93** (2024). (Forestry Forum 2023) https://doi.org/10.1051/bioconf/20249303007
31. G.A.Bahadirov, A.M.Nabiev, G.N.Tsoy, BIO Web Conf. **116**, (2024), EBWFF 2024. https://doi.org/10.1051/bioconf/202411607020
32. G.A.Bahadirov, A.M.Nabiev, G.N.Tsoy, F.R.Rakhimov, Izvestiya Vysshikh Uchebnykh Zavedenii, Seriya Teknologiya Tekstil'noi Promyshlennosti, **2 (410),** 164-171 (2024). DOI 10.47367/0021-3497_2024_2_164
33. F.R.Rakhimov, A.M.Nabiev, G.A.Bahadirov, AIP Conf. Proc. **3119 (1):** 060005 (2024). https://doi.org/10.1063/5.0214840