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GRINDING LEATHER AND FUR LEATHER FABRIC: DESIGN AND TECHNOLOGICAL SOLUTIONS

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ABSTRACT

The article presents a systematized overview of technological machines and devices, as well as technologies for grinding and finishing leather and fur leather fabric. The purpose of the work is to systematize and critically analyze the design solutions of grinding equipment, contact pressure reception and distribution systems, automated and robotic processing technologies, as well as to synthesize achievements in these areas and identify research gaps, in particular, on the influence of processing pressure on the quality of leather products. The design features of belt, drum, and buffer grinding machines, the mechanics of contact interaction of the abrasive tool with the leather, the system for forming and regulating contact pressure, as well as modern methods of automation and intelligent control of the process, are considered. Mechanical operations for surface treatment, the use of nonmaterial's in finishing coatings, and the processing of leather grinding waste were also considered.

Keywords: leather grinding, fur leather, abrasive processing, grinding machines, contact pressure, buffer machines, automation, finishing, processing pressure, nanoparticles, abrasion resistance.

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1. INTRODUCTION

Grinding leather and fur is a key mechanical processing operation in the leather industry. The primary objective of this operation is to achieve the desired geometric, roughness, and performance characteristics of the material's surface. Grinding ensures thickness leveling, removal of defective layers, improvement of surface adhesion, and preparation of the material for subsequent finishing operations [1], [2].

Unlike metals, leather is a complex, multicomponent fibrous composite material consisting of interwoven collagen fibers of complex hierarchical structure and pronounced anisotropy of mechanical properties. Mechanical stress on leather, including grinding, causes deformation, destruction, and redistribution of fibers, which determines the final physical and mechanical properties of the material [1], [3], [4]. Therefore, selecting rational design and technological parameters for equipment is critically important.

In today's environment, increasing product quality requirements necessitate the development of new equipment designs and the optimization of processing modes [5], [6], [7].

Grinding of fur leather is characterized by the presence of hair and high sensitivity of the leather base to mechanical stress. This requires precise control of process parameters and the development of specialized equipment designs [2].

Modern research demonstrates that grinding parameters significantly affect the surface integrity, microstructure, and functional properties of the material [8], [9]. This is especially important for fur leather, which has a more complex structure and is highly sensitive to mechanical stress.

Research confirms that grinding parameters directly affect the structural integrity, adhesion properties, and durability of leather materials [5], [6], [7]. Optimizing process conditions is a complex interdisciplinary task that involves contact mechanics, tribology, theology, and equipment design [9], [10], [11]. An additional challenge is the influence of material moisture content, which alters the elastic modulus, the strength of inter-fiber bonds, and the mechanism of structural failure [12]. This requires the development of adaptive processing modes and new equipment designs [13].

Leather is a fibrous elastic-viscoplastic material with pronounced anisotropy of mechanical properties. Its structure is based on collagen fibers, which form a three-dimensional network with high strength and elasticity. The hierarchical fibrous structure is formed by collagen fibrils, organized into fibers and bundles. The fibrous net consists of fibrils ranging in diameter from 50 to 500 nm. This structure provides high strength and flexibility to the material [3]. Mechanical processing partially destroys the surface layer and alters the morphology of the structure.

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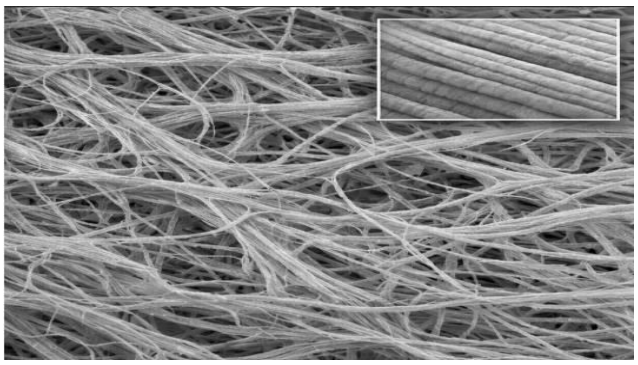


Figure-1. Microstructural state of collagen fibers in leather.

Research shows that mechanical processing of leather must account for its rheological properties, including elasticity, plasticity, and viscosity [1]. These properties determine the material's resistance to cutting and grinding. Incorrect selection of processing conditions can lead to structural damage and deterioration of performance characteristics.

The rheological properties of leather are described by viscoelastoplastic models, which take into account the elastic, plastic, and viscous components of deformation [1].

During grinding, abrasive grains interact with the fibrous structure, including mechanical destruction, plastic deformation, and fiber elongation. The destruction mechanism depends on the fiber direction, the degree of hydration, and the level of inter-fiber bonds [4].

Under mechanical action of abrasive grains, the following material removal mechanisms are implemented: micro-cutting of fibers; destruction of inter-fiber bonds; fiber elongation; plastic deformation of the structure [4], [8], [9]. Research shows that material removal occurs not only through cutting but also through the destruction of inter-fiber bonds and fiber elongation, which distinguishes leather grinding from metal processing [8].

An additional factor is the moisture content of the material, which significantly influences its mechanical properties and processing behavior [12]. Wetter leather exhibits high plasticity, requiring adjustment of process parameters. An increase in moisture content reduces the elasticity modulus, increases plasticity, and alters the mechanism of structural failure, as confirmed by studies of multilayer leather processing [12].

These mechanisms differ fundamentally from the processes of grinding wood and MDF, where material removal occurs primarily through cutting [14].

2. MATERIALS AND METHODS

The grinding process involves micro-cutting, plastic deformation, and friction between abrasive grains and the workpiece surface. During this process, abrasive grains (Figure-2) remove micro layers of material, creating the desired surface roughness [8].



a) b)

Figure-2. Materials used to manufacture abrasive grain: a) black silicon carbide, b) green silicon carbide

The mechanism of interaction between abrasive grain and skin involves several stages: contact, penetration, deformation, and material failure. Abrasive grain penetration depends on the contact pressure and the mechanical properties of the material [9].

The contact interaction between the abrasive tool and the material surface is determined by the pressure distribution, the speed of movement, and the characteristics of the abrasive [9]. These parameters influence the depth of grain penetration, the cutting force, and the intensity of tool wear. At low loads, elastic deformation predominates; as the load increases, plastic deformation begins, followed by fiber failure. This process is accompanied by the formation of microcracks and fiber separation [8], [10].

An additional mechanism is frictional interaction, accompanied by heat generation. Increasing temperature can lead to changes in the collagen structure and deterioration of material properties [11].

Research shows that the penetration depth of an abrasive grain is determined by the relationship between contact pressure and the elastic modulus of the material [9], [12]. When the critical stress is exceeded, the collagen structure is destroyed [4].

Frictional interaction, accompanied by heat generation, also occurs, which can lead to collagen denaturation and deterioration of material properties [11].

Thus, it was established that optimization of these parameters minimizes surface defects and improves machining quality [10]. Modern modeling methods make it possible to predict the behavior of the grinding process and optimize process conditions [11].

3. RESULTS AND DISCUSSIONS

3.1 Abrasive Tools and their Wear

Surface roughness is the main indicator of grinding quality. It depends on the abrasive grit, processing speed, and pressure [15].

Increasing grit reduces roughness and can reduce productivity. Increasing pressure improves productivity but increases the risk of damage to the material structure [16].

Processing speed affects heat generation and the nature of material failure. Optimal selection of parameters minimizes defects and ensures high-quality processing [9]. The primary tool for leather grinding is abrasive belts, which consist of a backing, a binder, and abrasive grains.

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The type of abrasive (Figure-3), grain size, and coating structure significantly affect processing efficiency [15].

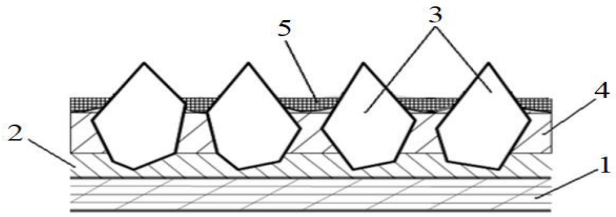


Figure-3. Sandpaper structure:
1 - backing; 2 - base binder layer; 3 - abrasive grains;
4 - bonding layer; 5 - dust-repellent coating

Structured abrasive materials provide more uniform load distribution and longer tool life [15]. Research shows that abrasive belt wear is one of the main factors affecting process stability [10]. Tool wear leads to reduced machining efficiency and changes in surface roughness [10], [15].

The use of modern abrasive materials can significantly improve machining quality and reduce energy consumption [9].

Modern Wear prediction methods based on neural networks allow for predicting tool condition and optimizing the process [10].

Research shows that structured abrasive materials provide more stable machining [15].

3.2 Equipment Design Features

Kinematic analysis of the mechanisms shows that motion transmission parameters have a significant impact on processing uniformity [9]. A rational feed system design ensures stable material positioning within the processing zone.

Optimization of feed and pressure parameters improves processing quality and reduces the risk of material damage [13], [16].

Based on the results of these studies, technical solutions were developed to improve the design of a leather grinding machine, and a patent certificate for a leather grinding machine №. IAP 8240 of the Republic of Uzbekistan was obtained. The purpose of this machine (Figure-4) is to expand the functionality of the leather grinding machine. The advantages of the machine over the considered grinding machines are that it increases the completeness of use of grinding sheet materials, smooths the skin folds and wrinkles, and increases its yield over the area.

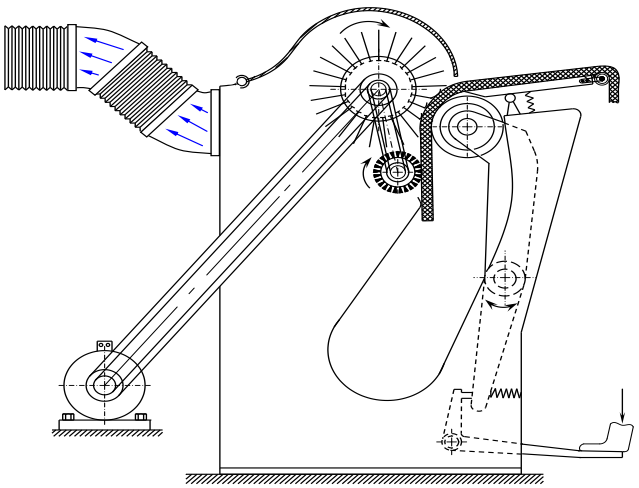


Figure-4. Schematic diagram of a leather grinding machine.

Belt grinding machines are the most common equipment for leather processing (Figure-5). They include a drive, belt tension system, working element, and material feed system [13], [20], [26].

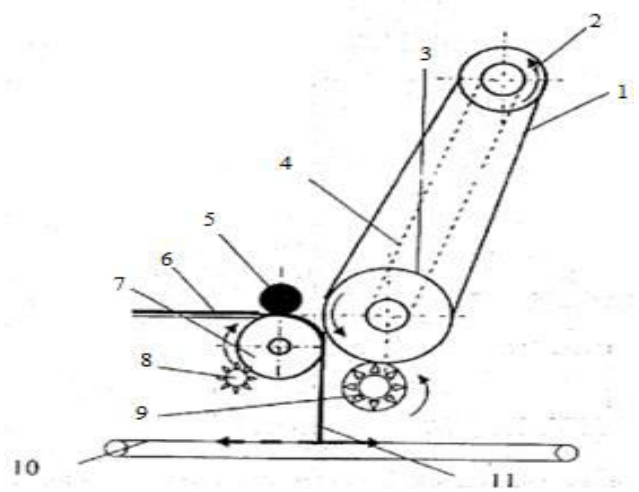


Figure-5. Schematic diagram of a belt device for leather grinding: 1 - abrasive belt, 2,3 - roller drums, 4 - chain drive, 5,7 - rollers, 6 - work table, 8,9 - brushes, 10 - conveyor, 11 - semi-finished leather product.

The use of modern drive systems ensures a stable processing speed and improves surface quality [17], [23]. Additionally, material deformation during transport between rollers must be accounted for [18].

3.3 Technological Parameters of the Process

The contact between the abrasive belt and the leather is a complex multipoint interaction. Contact interaction models take into account pressure distribution, material properties, and abrasive characteristics [9].

Modern models use finite element methods and analytical solutions to predict process behavior [11].

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The use of mathematical models allows for the optimization of process parameters and high processing efficiency [10].

The main process parameters are processing speed, pressure, abrasive grain size, and material feed rate. These parameters determine the material removal rate and surface quality [9].

Research shows that increasing pressure improves productivity but can lead to deterioration in surface quality, i.e., destruction of the skin structure [16].

Material moisture content has a significant impact on mechanical properties and processing parameters [12]. Optimal selection of parameters ensures a balance between productivity and processing quality.

Modern monitoring methods enable real-time process control and defect prevention [11].

Abrasive tool wear is one of the main factors affecting process stability. Wear leads to reduced productivity and deterioration in surface quality [15].

Wear prediction models enable process optimization and increased efficiency [10].

3.4 Modern Surface Modification Technologies

Modern technologies include the use of nonmaterial's and functional coatings to improve the surface properties of leather [6], [7], [19]. These technologies improve wear resistance, antibacterial properties, and resistance to external influences.

The use of titanium dioxide nanoparticles allows for the creation of functional surfaces with improved performance characteristics [6].

Modern technologies (Figure-6) are aimed at increasing wear resistance and improving the functional characteristics of surfaces [5].



a) b)

Figure-6. Physical side: a) wet blue; b) finished leather pieces, before and after grinding.

Recycling leather waste and using it as a functional material is a promising area [3], [4], [5].

Despite significant progress, unresolved issues remain, including the development of more accurate models and the creation of specialized equipment.

The grinding process is accompanied by dust formation and requires compliance with safety requirements [2]. Modern technologies are aimed at reducing environmental impact and increasing production sustainability [5], [24].

3.5 Research Gaps and Issues

Despite significant progress, several unresolved issues remain in this field, including the optimization of processing parameters, the development of new tools, and the automation of processes.

Based on a literature review, the following research questions can be formulated:

a) How does moisture content affect the mechanism of leather structure destruction during grinding? [4], [12];

b) How does abrasive tool wear affect the quality of the leather surface? [10], [15];

c) Which equipment parameters minimize structural damage? [13], [17];

d) In what ways can mathematical modeling enhance process efficiency? [9], [11];

e) How does the use of nonmaterial's affect the performance properties of leather? [6], [7], [19];

f) How do the destruction mechanisms of leather differ from those of wood and metal materials? [3], [8], [14].

Finding answers to these questions is essential for further technological development.

A promising direction for advancement is the integration of digital technologies and intelligent process control systems [10], [11].

The design of the grinding drum machine of the Turkish company "Ozdersan" is shown in Figure-7. From the middle of this working shaft to the right and left ends, grinding paper strips are attached along the screw (at a certain distance). With the help of such a design, the skin surface is polished, and an increase in the useful area is achieved [21].



Figure-7. Helical grinding work shaft.

Based on the foregoing, and utilizing existing analogues [22], we have arranged sets of stepped abrasive paper symmetrically along the surface of the grinding machine's working shaft (drum) using T-shaped metal bases and grooves. This configuration allows the grinding process to be carried out in relatively lighter modes (Figure-8).

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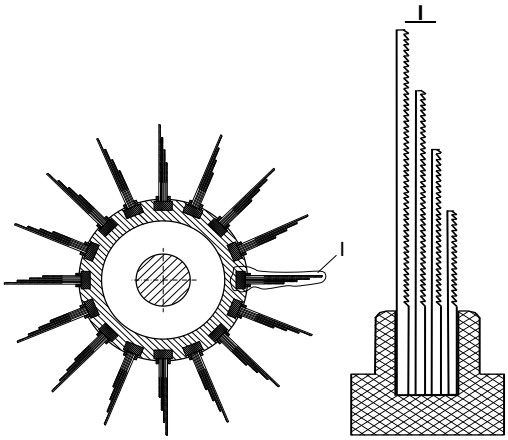


Figure-8. Advanced grinding drum diagrams.

Thus, in the technological process of grinding leather products, as a result of processing leather products in light (light) modes, an increase in their quality indicators is achieved [25]. The manufacture of the working grinding drum, developed based on the proposed technical solution, is relatively easy, and the replacement of grinding (abrasive) paper, which wears out during the technological processes performed, does not require much labor and time.

4. CONCLUSIONS

Leather grinding is a complex, multifactorial process that involves various mechanical, tribological, and rheological mechanisms [1], [9], [12]. This complexity requires an integrated approach to the design of equipment and the selection of process parameters. Current research focuses on improving processing quality, reducing costs, and enhancing product performance. Key areas of research include the optimization of processing parameters and the development of new equipment designs, both of which are essential for improving quality and reducing production costs [10], [11], [13].

Future research efforts should concentrate on creating innovative design solutions and optimizing processing technologies. Promising avenues for development include the creation of intelligent control systems, the use of nonmaterials, and the advancement of new abrasive tools [6], [7], [19].

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REFERENCES

[1] A. T. Amanov, G. A. Bahadirov, G. N. Tsoi, A. M. Nabiev. 2023. The Improvement of the Rheological Model of Leather. Int. J. Adv. Sci. Eng. Inf. Technol., 13(1): 321-328, doi: 10.18517/ijaseit.13.1.17360.

[2] UNIDO. 2021. Occupational Safety and Health Aspects of Leather Manufacturing. Vienna.

[3] M. Parisi *et al*. 2021. Recycling of chrome-tanned leather and its utilization as polymeric materials and in polymer-based composites. Polymers, 13(3): Art. 429, doi: 10.3390/polym13030429.

[4] X. Ding, Y. Li, J. Chen, X. Huang, L. Chen, Z. Hu. 2023. Sustainable utilization of finished leather wastes: A novel collagen hydrolysate-based gypsum additive with high-retarding performance. Process Saf. Environ. Prot., 172, 451-461, doi: 10.1016/j.psep.2023.02.040.

[5] C. Cirillo, M. Iuliano, C. Florio *et al*. 2025. High-performance leather finishing through zero-waste and metal-free leather waste valorization. Sci. Rep., 15, 18105, doi: 10.1038/s41598-025-03182-6.

[6] F. Fierro, M. Iuliano, C. Cirillo, C. Florio, G. Maffei, A. Loi, T. Batakliev, R. Adami, M. Sarno. 2024. Multifunctional leather finishing vs. applications through the addition of well-dispersed flower-like nanoparticles. Sci. Rep., 14(1): 2163, doi: 10.1038/s41598-024-51775-4.

[7] C. Cirillo *et al*. 2025. Silver Nanoparticle-Based Finishing for Leather: Antimicrobial and UV Protection. Micromachines, 16(4): Art. 376, doi: 10.3390/mi16040376.

[8] T. Zhang, Q. Wang, N. Wang, L. Yan, F. Jiang, E. Zhang, W. Zhou, H. Gao, Y. Wang. 2025. Surface Integrity in the Grinding of Hardened AISI D2 Steel. Materials, 18, 814, doi: 10.3390/ma18040814.

[9] Z. Wu, W. Fan, C. Qian *et al*. 2023. Contact Mechanism of Rail Grinding with Open-Structured Abrasive Belt Based on Pressure Grinding Plate. Chin. J. Mech. Eng., 36, 42, doi: 10.1186/s10033-023-00862-0.

[10] Y. Cao *et al*. 2021. Prediction of Abrasive Belt Wear Based on BP Neural Network. Machines, 9(12): Art. 314, doi: 10.3390/machines9120314.

[11] V. P. S. Pandiyan. 2019. Modelling and In-Process Monitoring of Robotic Abrasive Belt Grinding. PhD Thesis. Nanyang Technological University.

©2006-2026 Asian Research Publishing Network (ARPN). All rights reserved.

[12] A. T. Amanov, G. A. Bahadirov, G. N. Tsoi, A. M. Nabiev. 2022. Effect of Multilayer Processing of Semi-finished Leather Products. Int. J. Mech. Eng. Robot. Res., 11(4): 248-254, doi: 10.18178/ijmerr.11.4.248-254.

[13] G. Bahadirov *et al*. 2023. Determination of rational parameters of a device for leather feeding to the machining area. East.-Eur. J. Enterp. Technol., 2(1)(122): 62-72, doi: 10.15587/1729-4061.2023.277393.

[14] T. Palija *et al*. 2019. The impact of sanding system on the surface roughness of medium density fiberboard. Wood Ind. Eng. 1(1): 27-32.

[15] K. Serpin *et al*. 2015. Wear study of structured coated belts in advanced abrasive belt finishing. Surf. Coat. Technol., 284, 365-376, doi: 10.1016/j.surfcoat.2015.10.040.

[16] G. A. Bahadirov *et al.* 2023. The effect of roller pressure and feed rate on hides squeezing. E3S Web Conf., 402, 10016, doi: 10.1051/e3sconf/202340210016.

[17] G. A. Bahadirov *et al*. 2020. Kinematic analysis of tooth-lever differential transmission mechanisms. IOP Conf. Ser. Earth Environ. Sci., 614, 012101, doi: 10.1088/1755-1315/614/1/012101.

[18] G. Bahadirov, M. Musirov. 2022. Study of deformation of sheet material moving between rollers. AIP Conf. Proc., 2467, 060017, doi: 10.1063/5.0093197.

[19] M. Iuliano *et al*. 2024. Titania nanoparticles finishing for smart leather surface. Prog. Org. Coat., Art. 108457, doi: 10.1016/j.porgcoat.2024.108457.

[20] G. A. Bahadirov, A. M. Nabiev, G. N. Tsoi, K. Khusanov, L. E. Tursunboev, B. S. Igamberdiev, A. A. Sultanov. 2025. Machine for grinding leather. Patent No. IAP 8240. Intellectual Property Center under the Ministry of Justice of the Republic of Uzbekistan.

[21] Ozdersan. 2025. POL-130 1300 mm Polishing Machine. Available at: http://www.ozdersan.com.tr/en/products-detail-pol-130-1300-mm-polishing-machine/57 (accessed 10 Feb 2025).

[22] B. V. Zaitsev *et al*. 2013. New technical solutions for the leather industry. New in Engineering and Technology of Textile and Light Industry: Int. Sci. Tech. Conf., Vitebsk. 27-28, pp. 312-313.

[23] Г. А. Бахадиров, А. М. Набиев. 2025. Особенности и анализ конструкций барабанных машин для шлифования кожных полуфабрикатов. Вестник транспорта-Transport xabarnomasi. 2(1): С. 113-118.

[24] А. Набиев, Л.Э. Турсунбоев. 2025. Определение сил реакции опор прижимного устройства шлифовальной машины. Проблемы механики, №4, С. 113-120.

[25] Л. Э. Турсунбоев. 2025. Изучение барабанных машин для шлифования кожевенного полуфабриката. Экспериментальные и теоретические исследования в современной науке, №1(101): С. 64-68.

[26] Г. А. Бахадиров, А. М. Набиев, Г. Н. Цой, К. Хусанов, Л. Э. Турсунбоев, Б. С. Игамбердиев, А. А. Султанов. 2025. Чармни жилвирлаш машинаси. Ихтирога патент №IAP 8240. Ўзбекистон Республикаси Адлия вазирлиги ҳузуридаги Интеллектуал мулк маркази Расмий ахборотнома, №10(294).