LASER FINISHING IN THE DECORATION OF LEATHER PRODUCTS

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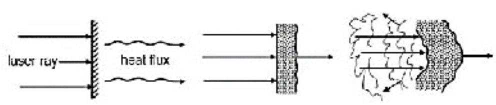
Today, the use of laser finishing of leather products is becoming more popular than traditional methods. However, there is not much information on the effect of laser energy on the leather structure during finishing, so additional research is need. Crust leather produced by a new unified resource-saving technology with the use of polymer compounds at the stage of tanning and liquid finishing was used for research. The different leather samples were taken for research the laser effect. Leather samples with a thickness of 1.40-1.45 mm were subjected to laser engraving at a depth of laser ablation from 0.1 mm to 0.7 mm in steps of 0.1 mm. It was found that the structure of the dermis under the action of laser radiation has not undergone morphological changes: the samples preserved the natural histological structure, collagen bundles are not deformed, the layers are evenly spaced without increasing the density of the structure. There is some increase in the distances between the structural elements of the dermis. It was found in the area of direct action of the laser beam there are signs of welding of collagen fibers, but on the surface of the sample of leather were no found chemicals substance. The influence of laser finishing on the structure and physical-mechanical properties of leather for footwear and leather goods was determined. It was found that increasing the depth of ablation to 50-52% of the thickness of the leather adversely affects it`s physical and mechanical properties, thereby deteriorating the performance of footwear and leather goods. The results of complex research of the effect of laser radiation on the physical and mechanical properties of the leather for the shoes uppers and leather goods allowed to establish rational technological parameters of the laser finish. Such information expands the possibilities of introducing laser equipment into serial production in order to create a modern range of finished products due to the creative design of models and unification of products.

Keywords: laser finishing, leather products, properties of leather.

INTRODUCTION

Replacing traditional intensive operations with laser technology opens up new opportunities for innovative solutions and is a key issue for the economic success of the footwear and leather goods industries. Today, laser technologies are used both for finishing materials and for the manufacture of products. Materials are processed at very high temperatures, which can cause melting or evaporation of almost any material due to the high concentration of power and energy in a very small area (Grigor'janc, 1989). However, due to the reasonable choice of technological parameters, the use of laser technology has recently become significantly more widespread, as it has a number of advantages over conventional methods and is becoming increasingly economically attractive for cutting and finishing leather products.



a b c

Figure 1. The sequence of action of laser radiation on natural leather: a) absorption and heating; b) melting; c) evaporation

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Most laser technologies were based on thermal action, the need to heat material a given temperature. The absorption of thermal energy for natural leather is volumetric view and the depth of penetration of laser radiation is determined by physical properties of the leather, which is an anisotropic inhomogeneous material (Fig. 1).

To determine the impact of thermophysical processes occurring during laser finishing on the physical and mechanical properties of natural crust leather for footwear and leather goods, a microscopic analysis of topological and morphological changes in the structure and indicators of physical and mechanical properties of leather

MATERIALS AND METHODS

Crust leather was produced using a new unified resource-saving technology using polymer compounds at the stage of tanning and liquid finishing. In addition, tanning includes pre-processing of abated pelt with a polymeric compound based on ethylene carboxylic acid instead of pickling, which allows us to decrease the duration of the process as well as the tanning agent consumption by 25 %. The liquid finishing includes using a polymeric compound based on maleic acid after the neutralization process (before dying), which allows us to decrease the processing duration by 20 %, dying agents and tannins consumption by 50 %, to increase the grade of quality, to increase the crust leather yield of thickness by 1.4 %, and area by 0.3 %. For comparison, used crust leather, made by a known technology (Andreyeva *et al*., 2019).

The effect of laser radiation on the microstructure of dermal collagen was examined using scanning electron microscopy (SEM) on a Tescan Mira 3 LMU (Czech Republic). For more complete information a first layer of conductive material in the form of platinum was sprayed on the front surface of the leather sample after laser finishing, which covered the surface of the sample and the area of direct action of the laser beam (Krishtal *et al*., 2009).

Crust leather finishing was performed on a CO2 laser machine Comelz CZ/M (Italy). Crust leather samples with a thickness of 1.40-1.45 mm were subjected to laser engraving at a depth of laser ablation from 0.1 mm to 0.7 mm in steps of 0.1 mm.

Stages of conducting the research: 1. Determination of the effect of laser radiation on the physical and mechanical properties of crust leather to establish the main dependencies between important indicators and parameters of laser ablation. 2. Establishing rational technological parameters of laser engraving. 3. Research of the effect of laser engraving on the structure of leather crust for the upper of shoes and leather goods

RESULTS

In order to determine the effect of laser radiation on the physical and mechanical properties of the leather, the effect of the depth and area of laser ablation on the parameters of the strength limit during stretching and elongation under a stress of 10 MPa was determined. The ablation depth varied from 0.1 mm to 0.7 mm, and the area was 1%, 25%, 50% of the working area of the tested sample. Cracking of the front surface of the samples occurred almost simultaneously with their rupture. The obtained values were compared with the values of leather samples without engraving. Based on the conducted studies, the effect of the depth of laser ablation on the strength limit

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during stretching was established (Fig. 2), while the ablation area of the samples was 1% of the working area of the sample.

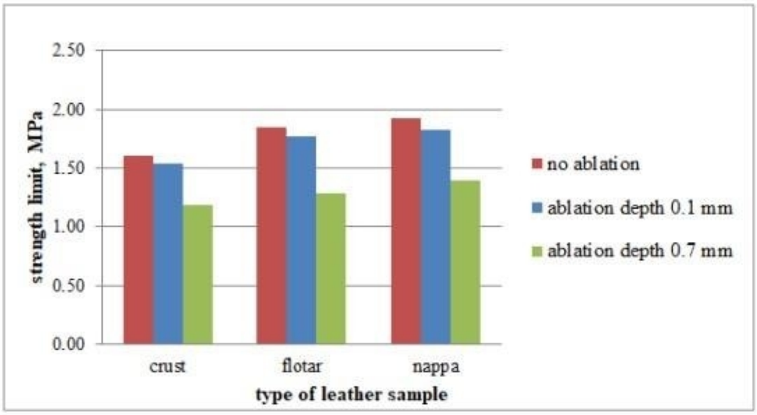

Figure 2. Diagram of the influence of the ablation depth on the strength limit

According to the results of the experimental research, it was determined that the increase in the area and depth of laser ablation affects the decrease in the tensile strength index. When the ablation area increases to 50% of the total area of the sample, and the depth up to 0.7 mm, the index of the tensile strength limit decreases by 1.1 times (Fig. 3).

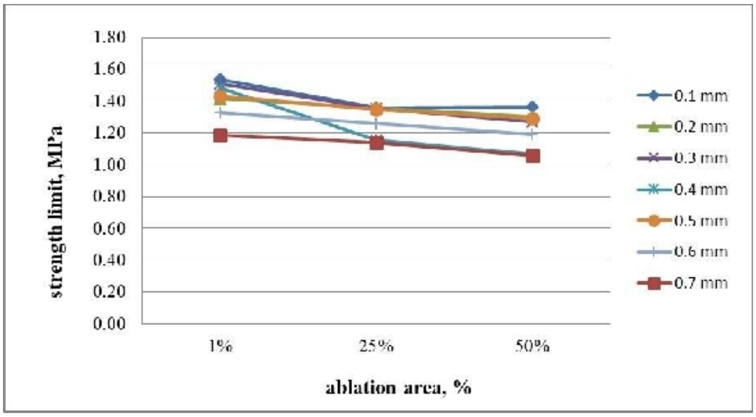

Figure 3. The influence of the area and depth of laser ablation on the strength resistance of crust leather

Based on the analysis of the obtained results, it is not recommended increase the area of engraved elements by more than 25-35% of the total area of the product part with an ablation depth of 0.3-0.4 mm on the relevant shoe parts. It is also not

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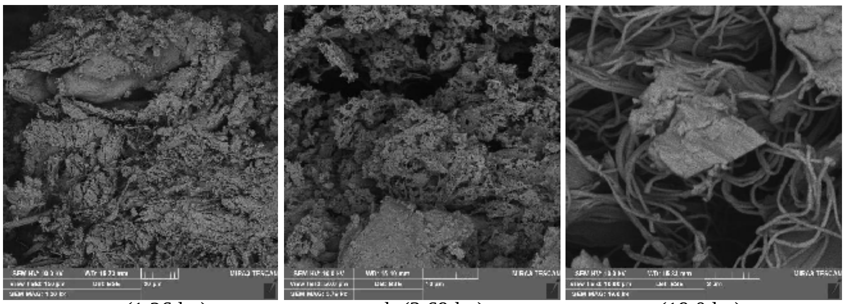
recommended increase the area of engraved elements by more than 40% of the area of the part with an ablation depth of 0.4-0.5 mm on the parts of leather goods.

According to the results of electron scanning microscopy it was found that the structure of the dermis under the action of laser radiation has not undergone morphological changes: the samples preserved the natural histological structure, collagen bundles are not deformed, the layers are evenly spaced without increasing the density of the structure (Fig. 4 a, b). There is some increase in the distances between the structural elements of the dermis (Fig. 4 c).

It was found in the area of direct action of the laser beam there are signs of welding of collagen fibers, but on the surface of the sample of leather were no found chemicals substance. There is no amorphous carbon, which turned the upper layer of leather removed from the area of engraving by gas flow.



a (1.26 kx) b (3.69 kx) c (19.0 kx)

Figure 4. Electron scanning microscopy image of the cross-section leather samples in the area of laser ablation

Such changes are a consequence of thermophysical processes, which depends on the absorption coefficient of the material, the wavelength of the laser and duration of exposure. The duration of laser radiation in turn determines the temperature and size of the heated layers.

Increasing the distance between the structural elements of the dermis determined to higher vapor permeability (Danylkovych, 2006; Rybalchenko *et al*., 2010). When the ablation depth increased to 0.7 mm (50% of the total thickness of the sample) compared to the sample without ablation, the skin vapor permeability increased by 5% (Borshchevska, 2020). As the ablation area increased to 50%, this indicator increased to 8.5%. This result is a consequence of the release of the capillary-porous structure of the leather. Physical and mechanical properties of the leather are preserved with a sufficiently fluffy structure. The tensile strength index varied from 15.0 to 12.5 MPa at a depth of laser ablation from 0.1 mm to 0.7 mm and a minimum ablation area of 1% of the working area of the sample

CONCLUSION

The depth of laser ablation, equal to 25-30% of the leather thickness, and the area of engraved elements less than 50% of the total area of the part are rational technological parameters for laser finishing leather, which provides good hygienic properties and does not impair the performance of products.

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The results of complex research of the effect of laser radiation on the physical and mechanical properties of the crust leather for the shoes uppers and leather goods allowed to establish rational technological parameters of the laser finishing. Such information expands the possibilities of introducing laser equipment into serial production in order to create a modern range of finished products due to the creative design of models and unification of products. (Fig. 5). Improving the aesthetic properties of leather products was achieved through the development of a unique design using laser engraving.

Figure. 5. Creative design of leather goods and shoos with using laser engraving

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