Resistance of the leather-rubber adhesive joint when making the shoe upper

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The professional literature dealing with specific aspects of adhesive joints in the footwear industry is mainly devoted to the procedures of preparation, bonding and testing of the connection between the upper and the sole material of fashion and sports footwear. However, there is little research related to the requirements and quality testing of adhesive joints of shoe upper parts. Safety and occupational footwear, which is intended for specific occupations such as firefighters, police officers, soldiers and others, as such has specific requirements in terms of resistance to various types of solvents, high and/ or low temperatures, shocks, etc., and in addition it should be comfortable and long-lasting. For these reasons, the upper of this type of footwear differs significantly from the footwear used in everyday life. It is usually a very complex construction and is made of a large number of different natural and artificial materials such as: leather, rubber, polyurethane, synthetic membranes, etc., which are interconnected by bonding or stitching. The aim of this study was to examine how the number of adhesive coatings and their characteristics affect the strength of the natural leather - rubber adhesive joint in the manufacture of shoes for special purposes. The strength of the leather-to-rubber adhesive joint depends significantly on the number of adhesive coatings and the viscosity of the adhesive.

INTRODUCTION

The key factors that should meet the requirements in terms of functionality, durability and aesthetic appearance of footwear, which are the main factors in the quality of footwear, primarily depend on the choice of material, but also the design and construction of footwear. When we talk about the quality of any type of footwear, it is necessary that it be designed and made in a way that the materials used are interconnected so that the model of footwear is fully functional during wearing, and to ensure durability and ease of movement.

The process of interconnection of the structural parts of footwear, which has the greatest use today, is reflected in the application of different types of adhesives, the choice of which depends primarily on the characteristics of the materials, but also on the strength of the adhesive joint to be achieved. Adhesives today play an important role in the footwear industry. The introduction of adhesive-bonding technology in footwear production has provided a number of advantages related to sewing or mechanical-bonding. Some of them are:

- The process is much faster, which allows a more efficient production;
- More flexible and homogeneous joints are obtained;
- Stresses during use are similarly distributed along the entire joint;
- Improved aesthetic properties are achieved, as fine, thin films of adhesive are used, so that the joint is invisible. In this way, new possibilities of shoe design were opened, which is especially important in fashion footwear; and
- Process automation.

However, adhesive bonding also has certain limitations. In order to avoid the problems of separating the joined parts, strict control of all steps in the process of forming the adhesive joint is required.

A wide range of materials used in footwear manufacturing, including natural and synthetic leather, nonwoven fabrics, rubber and other synthetic materials, requires the application of different types of adhesives, which are characterized by different performance. The method of surface pre-treatment of the bonding materials, the thickness of the adhesive film, wetting and drying time, and finally the cohesive strength of the adhesive joint depend on the

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characteristics of the adhesive. That is a reason why adhesive manufacturers, following the demands of the market, are constantly working on the improvement and development of new adhesives, which follow new adhesive-bonding technologies, all with the aim of achieving satisfactory bond strength and raising the quality of the finished product. Choosing the optimal adhesive to achieve durability and strength of the adhesive joint is not always an easy task, considering the variety of materials, but also the need for their pretreatment before adhesive bonding, which increases the complexity of the production process, but ensures better joint strength (Paiva et al., 2013).

The greatest use in the footwear industry has polyurethane and polychloroprene adhesives, which can be water-based or solvent-based, and the choice of which, depends on the applied materials and the required strength of the adhesive joint (Lucas et al., 2018). Water-based adhesives are in the form of an emulsion. Small polymer particles are suspended in water. Solvent-based adhesives consist of a polymer dissolved in an organic solvent, such as toluene, usually in a ratio of one part polymer to three or four parts solvent.

Polychloroprene adhesives can be used for all types of materials except polyvinyl-chloride, thermoplastic elastomers and polyurethanes. The advantage of using this type of adhesive is the ability to be immediately applied to the surfaces of all parts of the footwear. By heating with an infrared lamp, the solid adhesive film is reactivated and the parts of the footwear are joined. Polyurethane adhesives are the most popular adhesives in the footwear industry because they are compatible with a number of different materials. However, in order for polyurethane to bond to the surface of some materials, their pre-treatment must be performed. For example, natural and synthetic elastomers must be chemically processed in a process called halogenation. The introduction of new polymeric materials for the production of soles and uppers of footwear leads to new problems in the production of adhesives. It happens that additives, especially plasticizers, migrate from polymeric materials to the adhesive film. These chemical compounds do not affect polyurethane adhesives, which is another great advantage of them (Khan, 2015).

In addition to choosing an adequate adhesive to achieve the desired strength of the adhesive joint is crucial. The surface treatment method has substantial effect on final adhesion characteristic (Saikumar, 2002), given that this increases the strength and durability of the adhesive joint, but also overall functionality and the quality of the finished product. For the application in the surface treatment, it is necessary to take into account the materials which are intended to be bonded, in order for the choice of surface pretreatment to meet the ultimate requirements in terms of the quality of the connection. The strength of the adhesive joint must not be affected by: moisture, ultraviolet radiation, temperature changes or any other elements to which the footwear will be exposed. Four major types of surface treatments are available to use on the substrates: physical, chemical, primer, and solvent wipping (Snogren, 1974).

The porous structure of the leather facilitates and improves the bonding process, with faster diffusion of adhesives in the structure of the leather, especially when it comes to a treatment process that has in its application solvent-born polychloroprene adhesives. To obtain good adhesion of the adhesive joint, it is necessary to remove the weak surface layer of the leather by surface pretreatment of semi-chrome and vegetable-tanned leather, using rotating wire brushes that increase the surface roughness and remove its surface layer, reaching the corium, which is characterized by greater cohesion of collagen fibers. Removing the weak surface layer of the leather reduces the presence of greasiness and substances used in the leather finishing (gloss, varnishes, waxes etc.), which increases the strength potential of the adhesive joint. Surface pretreatment of the synthetic materials used in the fabrication of the upper also seeks to achieve surface roughness, which is achieved by treating the surfaces of the material with mild solvents, followed by application of two consecutive adhesive layers, to produce a good adhesive joint (da Silva et al., 2018).

Safety footwear must meet the highest quality and safety standards EN ISO 20345:2012 - Safety footwear. This footwear contains one or more protective components, which provide protection of the feet from mechanical injuries, a metal toecap in the front part, which, in addition to protection, provides a correct shape of the shoe (Mikulčić et al., 2019). Due to their excellent mechanical properties and comfort, natural high-quality tanned leather is most often used for their production. Tensile strength of natural leather can be up to 38 MPa, and the peel strength of 78 N/ mm (Li et al., 2021). The rubber reduces abrasion and increases safety.

It is usually done in small batches, as required by a particular profession, and consists of a large number of different parts. In order to perform proper modeling and production of footwear, it is necessary to know well the characteristics of all materials and their interconnection. For this research, a test of the resistance to delamination of the leather - rubber adhesive joint was chosen when making the upper of the safety footwear. Measurements were made on samples, test tubes that were taken from the semifinished product of the shoe, which is intended for the army and for work in extreme conditions. The standard DIN EN 1392: 2006-08 specifies the minimum strength values recommended for the connection of leather-rubber adhesive joint. It is very important that the leather and rubber withstand as much tearing force as possible, because rubber reduces abrasion of the upper and increases safety.

MATERIALS AND METODS

The experimental part of the paper consists of two phases. The first phase is the production of the upper parts for safety footwear. All treatments used in the footwear industry are applied. The preparation of samples of the upper for the boot was done in the company DERMAL R d.o.o Kotor Varoš, Bosnia and Herzegovina. The second step is to test the strength of the adhesive joint by measuring the separation force, according to ISO 17698 Footwear - Test methods for uppers - Delamination resistance. The measurement of the strength of the adhesive joint was performed in the Laboratory for Testing Materials at the Faculty of Technology in Banja Luka.

Materials

The safety boot must be made of a suitable material that should reduce the possibility of injury during various incident situations. In order to achieve adequate protection, but at the same time provide maximum comfort to the foot, with this type of footwear, apart from the steel toecap, which protects the foot from blows and crushing, the presence of rubber is desirable, precisely in the area of the toes, in order to additionally ensure the protection of the foot. Several different materials were used to create the upper of the safety boot:

 Two types of natural beef hydrophobic leathers that are chromium tanned with a large amount of grease, which is why they do not have a high gloss. To make the upper of this type of boot, the following were used: Regatta leather, brown, thickness 2.0 - 2.2 mm and Wapro leather, smooth, black, thickness 2.5 - 2.7 mm.

- Felt, which is sewn on the edge of the upper, width 1.0 -1.2 mm.
- Rubber that is bonded to the upper material and protects the shoe from abrasion, protects the inner membrane and the formation of pressed points.

The following substances were used for surface preparation and bonding of materials for making the upper:

- A mixture of commercial solvents and detergents under the trade name ISA VERDÜNNER 330 was used for washing the rubber.
- A two-component trichloroisocyanuric acidbased halogenating agent and 2,5-Thiophendiylbis (5-tert-butyl-1,3-benzoxazole), IcortinTM C40 F TEIL A were used to treat the surface of the rubber that sticks to the upper and protects the shoe from abrasion.
- For the first coating of the upper, a two-component polyurethane-based adhesive (Ultraflex[™] 4010 Y), manufactured by H. B. Fuller Austria, was used. It is intended for greasy, hydrophobic leather and loose fibers. It is used for leathers with over 12% m/m grease, which are intended for work and military footwear.
- For the second coating, one or two-component adhesive, based on polyurethane (Ultraflex[™] 4320) and organic solvents acetone and butanol, was used, and it is intended for bonding soles to the upper part of shoes, made of almost all types of materials (Emica et al., 2016). It is characterized by high heat resistance. The basic characteristics of the adhesives are given in Table 1.
- HÄRTER 1E-075 was used to accelerate the drying and curing of the adhesive. This additive is a solution of isocyanates in organic solvents, and 7% m/m is added to the total amount of the adhesive. In addition to faster drying, it has a positive effect on the structure of the adhesive, which ensures uniform surface coverage.

Property	Ultraflex [™] 4010 Y	Ultraflex [™] 4320
Colour	Colourless - limpid	Transparent
Solid content, %	Approx. 24	Approx. 18
Density, g/cm³	0.88	0.86
Viscosity (Brookfield RVT, at 20°C), mPa·s	Approx. 450	Approx. 2800
Activation temperature, °C		65 - 70

Table 1. Adhesive properties

Methods of preparation of materials and samples

Before bonding, it is necessary to prepare the surface of the material. The aim of the preparation is to achieve a better connection between the surfaces and the optimal adhesive strength of the adhesive joint. It is a well-known rule that proper surface preparation avoids most problems in bonding processes in the footwear industry. Depending on the type of material, these can be mechanical operations, such as brushing, or chemical operations, such as oxidation or halogenation. More aggressive chemicals are used in less porous materials, such as natural and synthetic elastomers, to obtain a rougher, more porous surface into which the adhesive will penetrate more easily. With natural leather, it is enough to mechanically remove the surface layer with wire brushes to achieve good adhesion. Whether the intensity of brushing will be stronger and deeper or milder, depends on whether there is a finish on the surface and what the grease content is. The deeper porosity of the leather allows the formation of a stronger bond, while the grease content above 11% m/m can interfere with bonding. The chronology of shoe operations is shown in Figure 1.

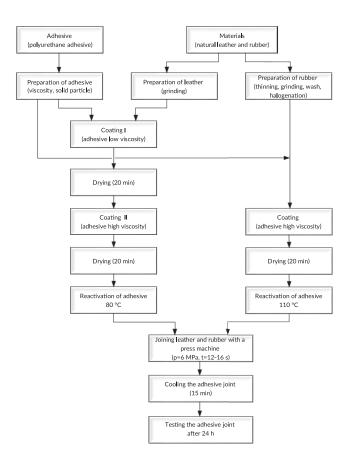


Figure 1. Schematic representation of the process of creating an upper

The preparation of the first sample of vamp for testing is divided into several operations: Edging trimming / thinning is performed on thickness equalizing machine (scharf-maschine). The operation is performed to reduce the thickness of the rubber due to the easier joining of the shoe parts. Scratching/grinding the rubber is an operation performed to remove the surface layer of the rubber, for easier adhesion to the leather. It is performed mechanically. Rubber is washed manually with ISA VERDÜNNER 330. After washing, rubber is dried at room temperature for 20 minutes. Halogenation is a wet process of modifying the surface of elastomers (rubber, styrene butadiene, ethylenepropylene-dimer terpolymers, etc.) in order to increase the adhesion of the adhesive to the surface, and thus the strength of the joint. For these purposes, solutions of Nahypochlorite, Chloramine - T, trichloroisocyanuric acid (TCIC) are used. After treatment with halogenating agents, an increase in adhesion of 4 to 20 times was measured (Lucas et al., 2018). In order to avoid overtreatment of the polymer, which can cause tearing of the polymer chains and a smaller effect of adhesive adhesion, this type of treatment must always be optimized for a particular application. It is performed manually and lasts 60 minutes at room temperature. Component splitting is an operation that is performed to reduce the thickness of the leather due to the easier joining of the parts of the footwear, as well as due to the aesthetic appearance of the boot. It is performed mechanically using a split machine.

After the preparation of the leather surface and elastomer, two successive layers of adhesive are applied to obtain good bonded joints. *Ultraflex*TM 4010 Y adhesive was used for the first coating. The first coating of the upper is usually done by one-component adhesive, but given the frequent requests of external partners to use two-component adhesive, the research was done this way.

The adhesive dries for 20 minutes at room temperature. Then a second coat of adhesive of the same type, *Ultraflex*TM 4320 Y, is applied. *Ultraflex*TM 4320 adhesive is applied only onto the rubber. Coating of both leather and rubber is done manually, and drying takes 20 minutes at room temperature. Reactivation of the adhesive is performed by heating at a temperature of 80°C, while activation of the adhesive on the rubber is performed by heating at a temperature of 110°C. Reactivation is required to soften the adhesive and achieve optimal tack. The bonding is done while it is hot, and the upper with the rubber is placed in the press under the pressure of 0.6 MPa for 12-16 seconds (Figure 2).



Figure 2. Pressing machine

By cooling the upper for 15 minutes at room temperature, there was a permanent crosslinking of the adhesive, which means that the process of curing the adhesive is irreversible. The adhesive joint is heat resistant. If the adhesive layer is exposed to high temperatures, it can only decompose, but not soften (Paiva et al., 2015).

The procedure for preparing the second sample is performed in the same order of operations as the first sample. In the bonding process, the operation of applying a second coat of adhesive was omitted. The sample is stored at room temperature. After 24 hours it is optimal time to test the tear resistance on the dynamometer. In this test, no measurements were made after 24 hours, but due to the fact that the bonded joints are subject to changes in mechanical properties over time, all measurements were performed within a month of the bonding process.

After the samples are formed, it is necessary to prepare test tubes to determine the breaking force, when layering the natural leather – rubber adhesive joint. To test the strength of the joint, the complete upper of the shoe was not taken into account, but the vamp of the upper from which two samples (tubes) were separated, in such a way that the bonded layer contained all types of materials, as shown in Figure 3.

In addition to the characteristics of the materials, adhesive, and the bonding process, pressure, temperature, humidity, time, adhesive layer thickness, etc., an important parameter that affects the strength of the adhesive joint is the length of the overlap. Therefore, in order to avoid the influence of this characteristic, all tests were performed on test tubes whose shape and dimensions are shown in Figures 4–5.

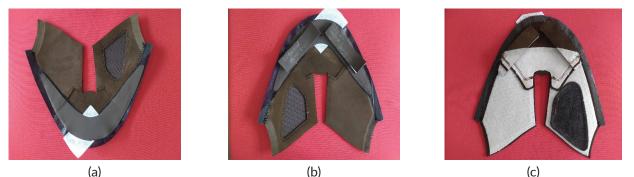


Figure 3. Prepared shoe upper (a) –face, (b) – cutting the test tube and (c) –reverse side

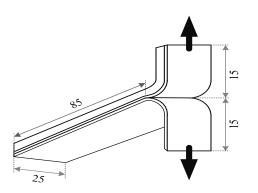


Figure 4. Geometry of the tube of the adhesive joint for testing the resistance to delamination



Figure 5. Prepared samples for testing the strength of the adhesive joint

Method

To determine the strength or resistance to delamination of the bonded joint, an automatic dynamometer of the brand "Schimadzu" with hydraulic drive, loaded with a cell of 5 kN was used. The distance between the clamps was 20 mm, and the speed of movement of the upper clamp was set according to ISO 17698 to 100 mm / min \pm 20 mm / min.

Prepared tubes of each sample should be opened individually in the unbound part, taking care not to weaken the bond line. The ends of the tube are then secured in the space between the dynamometer clamps, taking care that the unbound part of the rubber is clamped inside the upper clamp and the unbound part of the leather in the other clamp, as shown in Figure 7.

After all parameters have been set, the dynamometer is put into operation until the moment when the test tube bursts, or until the moment when the breaking force becomes greater than the resistance of the tested test tube. The device continuously measures the force and draws a force-elongation diagram, as shown in Figure 8. The average force is divided by the average tube width (N/mm). Breaking characteristics, that is, delamination forces, were determined as the mean value of ten measurements, in the case of twocoated test tubes, and five measurements in the case of test tubes with the second coating omitted.

Also, it is necessary to record the type of separation that potentially occurs, by the action of the force that delaminate the adhesive joint. The type of separation can provide useful information about the performance of the adhesive joint, which parameters need to be improved, such as material cohesion, activation heat, surface treatment, adhesive viscosity, etc. Separation types are usually described as follows:

- failure of the adhesion of the coating to the base fabric, resulting in the separation of the adhesive film from the material;
- surface failure of the base fabric, resulting in the cohesive damage to the surface of the material;
- deep failure of the base material, resulting in the cohesive cracking of one of the surfaces.
- failed coalescence failure of the adhesion of a top coating to a cellular coagulated coating, due to which there is a separation between the films of the two adhesives, without separation from the material;
- separation between a cellular or coagulated layer and the base material - resulting with a separation of the adhesive film from one of the materials.

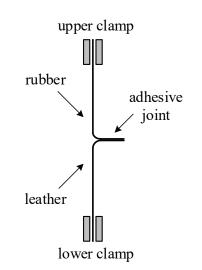


Figure 6. Principle of testing the strength of the adhesive joint

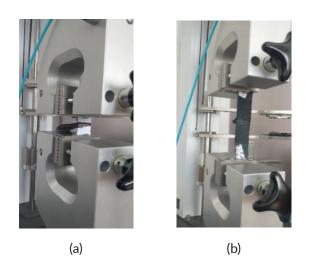


Figure 7. Test tube: placement between dynamometer clamps (a) and the stretching of the sample (b)

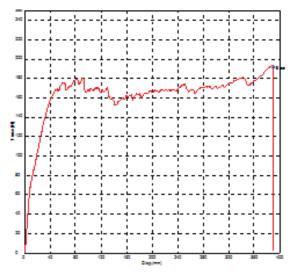


Figure 8. Load - deformation diagram

RESULTS AND DISCUSSION

Table 2 and Table 3 present the results of the delamination resistance test samples prepared with two adhesive coats of brown *regatta* leather (R_2) and black *wapro* leather (W_2). The test results of delamination resistance samples, which were prepared from the same materials and technologically processed in the same way as samples R_2 and W_2 , but with the omission of the second adhesive coating (designated as R_1 and W_1), are shown in Table 4 and Table 5.

The measurement results shown in Tables 2-5 and graphically in Figure 9, show that the vamp prepared from brown leather with two coats of adhesive shows a higher strength of the adhesive joint than the vamp prepared in the same way from black leather. All brown leather samples meet the set requirements of 3.5 N/ mm, while for the black leather samples $W_2 - 8$ and $W_2 - 10$ do not meet this requirement. Delamination strength of 3.5 N/mm is a common requirement of the manufacturing partner which enables guaranteeing a product shelf life of 4 years. Both leathers are brushed, but brown is more porous, which allows easier and better impregnation with softened adhesive. Brown leather is thinner and more elastic than black leather.

Table 2.Delamination resistance test results of vamp from brown leather - two coats of adhesive

		•	
Sample label	d (mm)	F _{sr.} Medium delaminating force (N)	Delamination strength (N/mm)
R ₂ - 1	25.00	118.42	4.74
R ₂ - 2	25.00	132.44	5.30
R ₂ - 3	25.00	101.69	4.07
R ₂ - 4	25.00	129.76	5.19
R ₂ - 5	25.00	175.30	7.01
R ₂ - 6	25.00	117.71	4.71
R ₂ - 7	25.00	158.75	6.35
R ₂ - 8	25.00	113.78	4.55
R ₂ - 9	25.00	125.45	5.02
R ₂ - 10	25.00	127.88	5.12
\overline{x}	25.00	130.12	5.20
Σ	0	21.75	0.87
CV	0	16.72	16.72

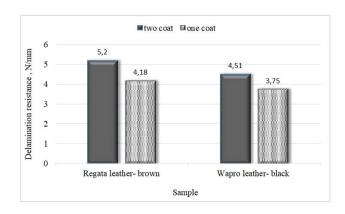


Figure 9. Dependence of the strength of the adhesive joint on the materials used

By omitting one coat of adhesive, in both samples of vamps there is a decrease in the strength of delamination, with advertising for brown leather reduction 19.6%, and for advertising of black leather 16.9%. Two black leather samples do not meet the minimum recommended value. For the first coating of vamp, a low-viscosity adhesive was used, which more easily enters the pores between the collagen fibers and moist leather surfaces. The same type of adhesive

 Table 3. Delamination resistance test results of vamp

 from black leather
 - two coats of adhesive

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Sample label	d (mm)	F _{sr.} Medium delaminating force (N)	Delamination strength (N/mm)
W ₂ - 1	25.00	107.83	4.31
W ₂ - 2	25.00	90.35	3.61
W ₂ - 3	25.00	187.09*	7.48*
W ₂ - 4	25.00	114.02	4.56
W ₂ - 5	25.00	141.34	5.65
W ₂ - 6	25.00	163.70	6.55
W ₂ - 7	25.00	107.87	4.31
W ₂ - 8	25.00	81.28	3.25
W ₂ - 9	25.00	123.75	4.95
W ₂ - 10	25.00	85.40	3.42
\overline{x}	25.00	112.84	4.51
σ	0	34.62	1.38
CV	0	30.68	30.68
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*W₂ – 3 not taken into account when processing the results

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Sample label	d (mm)	F _{sr.} Medium delaminating force (N)	Delamination strength (N/mm)
R ₁ - 1	25.00	90.71	3.63
R ₁ - 2	25.00	109.15	4.37
R ₁ - 3	25.00	108.38	4.34
R ₁ - 4	25.00	109.98	4.40
R ₁ - 5	25.00	104.56	4.18
\overline{x}	25.00	104.56	4.18
Σ	0	9.25	0.37
CV	0	8.85	8.85

 Table 4. Delamination resistance test results of vamp

 from brown leather
 - one coat of adhesive

Table 5. Delamination resistance test results of vampfrom black leather- one coat of adhesive

Sample label	d (mm)	F _{sr.} Medium delaminating force (N)	Delamination strength (N/mm)
W ₁ - 1	25.00	101.06	4.04
W ₁ - 2	25.00	78.98	3.16
W ₁ - 3	25.00	101.28	4.05
W ₁ - 4	25.00	87.20	3.49
W ₁ - 5	25.00	100.36	4.01
\overline{x}	25.00	93.77	3.75
Σ	0	12.81	0.51
CV	0	13.66	13.66

was used for the second coating, but over six times higher viscosity, which is more difficult to penetrate into the pores, which is why it lags on the leather surface and creates a homogeneous adhesive layer of high cohesion, which is reflected in the strength of the adhesive.

CONCLUSIONS

Making safety footwear is a process that requires many operations, modern machines, skilled labor, high quality leather, membranes and other materials, which results in high production costs and high prices of the final product. Any saving of material, time or labor enables the development of lower cost products and faster marketing of goods.

The adhesive leather-rubber joint, when making a special-purpose shoe, which is prepared with two coats of adhesive, has 15-20% higher resistance to delamination than the joint with one coat of adhesive, and strongly depends on the viscosity of the adhesive. For this reason, the omission of a single coat of adhesive cannot be considered as a saving option, but what could be further explored is how the thickness of the coating of high-viscosity adhesive affects the strength of the bonded joint.

REFERENCES

- Li, H., Zheng, W., Xiao, H., Hao, B., Wang, Y., Haung, X., & Shi, B. (2021). Collagen fiber membranederived chemically and mechanically durable superhydrophobic membrane for high performance emulsion separation. *Journal of Leather Science and Engineering*, 3(1), 1-10. https:/doi.org/10.1186/s42825-021-00060-5
- Emica, V., Akalović, J., & Zorić, S. (2016). Ovisnost sile razdvajanja gornjišta od potplata o vrsti ljepila i tehnologiji spajanja [Dependence of the force of separation of the upper from the sole on the type of adhesive and the bonding technology], *Koža i Obuća*, 1(3), 16–19. <u>https://www.hdko. hr/wp-content/uploads/2018/01/2016_1-3_ ovisnost_sile_razdvajanja_gornjista_od_ potplata_o_vrsti_ljepila_i_tehnologiji_spajanja. pdf_</u>
- Khan, M. R. (2015). Study About Polymer Applications in Footwear, [Degree Thesis], Arcada University of Applied Sciences, Helsinki, Finland. <u>http://</u> urn.fi/URN:NBN:fi:amk2015080513910
- da Silva, L. F. M., Öchsner, A., & Adams, R. D. (2018). Handbook of adhesion technology. 2nd Second Edition. Springer International Publishing. https://doi.org/10.1007/978-3-319-42087-5
- Mikulčić, M., Kovačević, S., & Skenderi, Z. (2019). Materials for production of protective boots for workers in forestry. *Koža i Obuća*, 68(1), 32–41. https://hrcak.srce.hr/file/322719

- Paiva, R. M. M., Marques, E. A. S., de Silva, L. F. M., António, C. A. C., & Aràn-Ais, F. (2016). Adhesives in the footwear industry. *Journal of Materials: Design and Applications*, 230(2), 357–374. <u>https://doi. org/10.1177%2F1464420715602441</u>
- Paiva, R. M. M., Marques, E. A. S., de Silva, L. F. M., & Vaz, M.A. P. (2013). Importance of surface treatment in the peeling strenght of joints for the shoes industry. *Applies Adhesion Science*, 1(5), 1-15. https://doi.org/10.1186/2196-4351-1-5
- Saikumar, C. (2002). Adhesive in the leather industry-perspectives for changing needs. Journal of Adhesion Science and Technology, 16(5), 543-563. <u>https://doi.</u> org/10.1163/156856102760070367
- Snogren, R. C. (1974). *Handbook of surface preparation*. New York: Palmerton Publishing CO., Inc.

Otpornost lijepljenog spoja koža-guma kod izrade gornjišta cipele

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Ključne riječi: ljepilo, lijepljeni spoj, otpornost na razdvajanje, prirodna koža, guma.

Stručna literatura koja se bavi specifičnim aspektima lijepljenih spojeva u industriji obuće uglavnom je posvećena postupcima pripreme, lijepljenja i ispitivanja povezanosti gornjišta i potplatnog materijala modne i sportske obuće. Međutim, postoji malo istraživanja vezanih za zahtjeve i ispitivanje kvaliteta lijepljenih spojeva dijelova gornjišta obuće. Zaštitna i radna obuća, koja je namijenjena za specifična zanimanja kao što su vatrogasci, policajci, vojnici i druga, kao takva ima specifične zahtjeve u pogledu otpornosti na razne vrste rastvarača, visoke i/ili niske temperature, udarce i drugo, a pored svega treba da je udobna i dugotrajna. Iz tih razloga gornjište ovog tipa obuće se značajno razlikuje od obuće koja se koristi u svakodnevnom životu. Najčešće je veoma složene konstrukcije i napravljeno od velikog broja različitih prirodnih i vještačkih materijala kao što su: koža, guma, poliuretan, sintetičke membrane i dr, a koji su međusobno povezani lijepljenjem ili prošivanjem. U zavisnosti od zahtjeva kvaliteta obuće, odgovarajuća jačina lijepljenog spoja se postiže primjenom različitih tipova i ljepila. Gornjište cipele, koje je bilo predmet ispitivanja, izrađeno je od prirodne viokokvalitetne štavljene kože, zbog njenih odličnih mehaničkih svojstava i udobnosti, i gume koja smanjuje habanje cipele i povećava sigurnost prilikom nošenja. Uzorci su pripremljeni od dvije vrste kože: smeđe regata kože i crne wapro kože. Eksperimentalni dio rada je obuhvatio izradu gornjišta čizme za specijalne namjene u fabrici obuće i određivanje sile razdvajanja lijepljenog spoja pomoću automatskog dinamometra. Za svaki uzorak je urađen veći broj mjerenja, na osnovu kojih je računata srednja vrijednost. Cilj ovog rada je bio ispitati na koji način broj premaza ljepila i njihove karakteristike, utiču na jačinu lijepljenog spoja prirodna koža – guma, u proizvodnji obuće za posebne namjene. Postoji značajna razlika jačine spoja u zavisnosti od broja premaza ljepila i viskoznosti ljepila, a određeni broj uzoraka nije zadovoljio ni minimalnu preporučenu vrijednost čvrstoće.