ASPECTS REGARDING THE PHYSIOLOGICAL AND COMFORT PARAMETERS IN SHOES MADE OF LEATHER SUBSTITUTES

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The issue of replacing natural leather with leather substitutes is increasingly common in the leather goods industry. In this paper, it was addressed the issue of ensuring the physiological and comfort parameters when wearing leather substitute shoes. The aim of the paper is to analyze how the sanogenetic indicators influence the hygienic properties of footwear products starting from the porosity of the materials subjected to experimental determinations. Poromeric skin substitutes will be used, which allow the passage of water vapor and air. Both types of leather substitutes for shoe uppers and some types of textile materials for linings will be subjected to laboratory analysis, using the pycnometric method. In conclusion, the values obtained for porosity fall between 47 and 58%, limits also provided by the specialized literature. It is noted that the porosity values of leather substitutes are close to those of chrome-tanned leather, so as a result, the value of leather substitutes use will increase (they have sanogenetic properties similar to natural leather). Currently, leather substitutes are used more and more in the manufacture of footwear products, because they maintain a thermal transfer balance between the foot and the surrounding environment, favoring the elimination of moisture produced by the foot when wearing the footwear in the outdoor environment.

Keywords: leather substitutes, porosity, comfort.

INTRODUCTION

Footwear products made of leather substitutes have an increasing tendency to look like those made of natural leather (Cociu and Mălureanu, 1993), but there are still problems related to their functionality, given by the state of comfort they give to the body. Thus, footwear products must ensure both the physiological needs and the protection of the body from the environment, and the required properties are (Porav and Secan, 2016a; Porav and Secan, 2016b): water vapor permeability (SR 9123:1994), absorption desorption (SR 8994/1:1994), lightness, resistance to water seeping, thermal insulation capacity, etc. During wearing, the hygienic, physical-mechanical and thermal properties are of particular importance.

The foot temperature in shoes with natural leather uppers is **lower** than in those with leather substitute uppers, and the relative humidity in shoes with natural leather uppers is approx. 64% compared to that with substitute uppers that is approx. 78% (Malureanu and Mihai, 2003).

Leather substitutes have a poly-layered structure, and the layers are made of polyvinyl chloride or other vinyl polymers on a textile support and can be poromeric, which allow the passage of water vapor and air, or non-poromeric, which do not possess hygienic properties (Bucevschi, 1984; Bucevschi and Negreanu, 1990).

Porosity is the most important property with a role in mass transfer or thermal insulation, by pore understanding the space occupied by the gaseous phase and delimited by the solid phase. Thus, natural leather being a capillary-porous system, after tanning, it has its own porosity, but in the case of leather substitutes, the porosity must be created by expansion, in their manufacturing process (Secan, 2008a; Secan and Mitu, 2008; Secan, 2008b).

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The present paper presents the results of the research on the porosity of some leather substitutes and textile materials for uppers and linings.

THE EXPERIMENTAL PART

In order to highlight how the sanogenetic indicators influence the hygienic properties of footwear products (SR 8994/15:1994), materials with different structures are studied, which generally represent leather substitutes intended for the manufacture of shoe uppers, but also textile materials for linings, that have undergone some experimental determinations.

Simple replacement samples were used that were numbered from 1...7, but also textile samples numbered from 1...8. The respective number actually represents the code of the material.

The description of the materials and their destination is presented below (Secan, 2010):

- The following types of substitutes are used for uppers:
    - Material 1 - substitute PVC type on tricot used for uppers;
    - Material 2 - substitute PVC type material on both uppers;
    - Material 3 - substitute material of PVC type on non-woven for uppers;
    - Material 4 - substitute PU type material on the fabric layer used for the uppers;
    - Material 5 - substitute of PVC/knitted fabric type used for uppers;
    - Material 6 - substitute PU type/non-woven material used for uppers;
    - Material 7 - upper fabric.
- For linings we have the following types of textile materials:
    - Material 1 - thermo-adhesive fabric used for lining the shoe top;
    - Material 2 - non-woven material used for lining the heel counter stiffener;
    - Material 3 - substitute material of PU type on non-woven surface used for linings;
    - Material 4 - fine cloth fabric used for intermediate lining;
    - Material 5 - substitute PU type material on non-woven backing used for linings;
    - Material 6 - is identical to material 3;
    - Material 7 - impregnated fabric for lining the shoe top;
    - Material 8 - fabric used for intermediate linings.

Porosity is determined with the relationship (Mitu, 2000):

$$P_z = \frac{\gamma_r - \gamma_a}{\gamma_r} \cdot 100\% \qquad (1)$$

γ_r– the actual specific mass or density of the material (kg / m^3);

γ_a– volumetric mass, i.e., the mass of the unit volume of material, including the pore volume.

The real specific mass or density of materials is determined taking into account their real, inhomogeneous structure. The method is based on immersing the material in certain non-polar liquids, which have the ability to displace air from the pores of the material. Such liquids are: toluene, nitrobenzene, benzene, etc.

The volumetric mass is calculated with the relation (Mitu, 2000):

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$$\gamma_a = \frac{Ms}{\delta \cdot 1000} \text{ (g / cm}^3\text{) or kg / m}^3 \qquad (2)$$

M_s–mass per unit area, (g / m^2)
δ–material thickness, mm.
Knowing the dimensions **a** and **b** of a sample of material, as well as its mass Mm expressed in grams, the mass of the surface unit MS is established, with the relationship (Mitu, 2000):

$$Ms = \frac{M_m \cdot 10^4}{a \cdot b} \text{ (g / m}^2\text{)} \qquad (3)$$

Mm - mass of the material sample, (g)
a and **b** is the size of the sample in cm.
The actual specific mass or density of the material is determined using the pycnometric method which is based on weighing the sample in air, obtaining the Mm value and then introducing it into the pycnometer with the chosen liquid, which will displace the air from the pores of the material.
The density calculation relation is the following (Mitu, 2000):

$$\gamma_r = \frac{Mm}{Vm} = \frac{Mm}{\frac{M_2 - M_1}{\gamma_\varphi}} = \frac{Mm \cdot \gamma_\varphi}{M_2 - M_1} \qquad (4)$$

where:
M_2 –represents the pycnometric mass of liquid and immersed sample, g;
M_1 –mass of pycnometer with liquid, g;
V_m –sample volume, cm^3;
γ_φ –the density of the immersion liquid used (in the case of toluene).
γ_φ = 0.867 g / cm^3.

RESULTS AND INTERPRETATIONS

The porosity of the materials subject to the determinations is presented in Table 1, respectively Table 2.

Table 1. Porosity of leather substitutes for shoe uppers

No.	Sample mass Mm (g)	Thickness d (mm	Mass per unit area Ms(g/m^2)	Volumetric mass γ_a (g/cm^3)	Mass of pycnometer with liquid M1 (g)	Mass of pycnometer with liquid and sample M2 (g)	Specific mass or density γ_r (g/cm^3)	Porosity Pz (%)
1	0.176	1.13	440	0.389	66.428	66.599	0.887	56.16
2	0.192	0.9	480	0.533	65.803	65.986	0.909	41.43
3	0.22	1.09	550	0.504	65.389	65.608	0.87	42.179
4	0.141	0.63	352.5	0.559	65.057	65.173	1.05	47.12
5	0.147	1.02	367.5	0.36	64.403	64.545	0.897	59.92
6	0.194	1.16	485	0.418	64.016	64.203	0.899	53.55
7	0.095	0.99	237.5	0.239	65.978	66.071	0.885	73.06

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Table 2. Porosity of textile materials for linings

No.	Sample mass Mm (g)	Thickness d (mm)	Mass per unit area Ms (g/m^2)	Volumetric mass γ_a (g/cm^3)	Mass of pycnometer with liquid M1 (g)	Mass of pycnometer with liquid and sample M2 (g)	Specific mass or density γ_r (g/cm^3)	Porosity Pz (%)
1	0.147	0.7	367.5	0.525	67.139	67.284	0.879	40.31
2	0.13	0.86	325	0.377	66.855	66.972	0.963	60.88
3	0.19	0.8	475	0.593	66.57	66.732	1.01	41.96
4	0.074	0.33	185	0.56	65.61	65.68	0.9165	57.83
5	0.123	0.75	307.5	0.41	64.896	65.015	0.896	54.24
6	0.151	0.83	377.5	0.454	64.652	64.796	0.909	50.07
7	0.084	0.46	210	0.456	64.526	64.605	0.92	50.63
8	0.077	0.35	192.5	0.55	63.724	63.795	0.94	41.51

Taking into account the importance of the porosity owned by the materials used only for shoe uppers, the following graph is presented below:

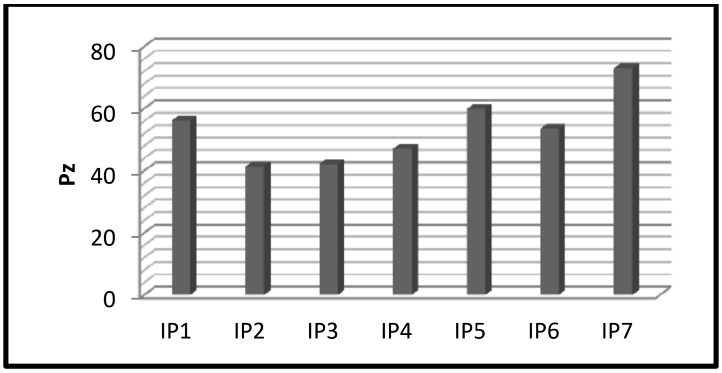

Figure 1. Porosity variation for types of substitutes intended for shoe uppers

In Figure 1, higher porosity values can be observed for material 2 woven type, followed by PU polyurethane on tricot support and PVC polyvinyl chloride on tricot support (material 6 and material 1). There are lower values for the PU polyurethane substitute, on a non-woven support (material 7). Impregnated or printed materials (materials 5, 4, 3) have lower porosity values.

Figure 2 shows the porosity variation for textile materials intended for linings.

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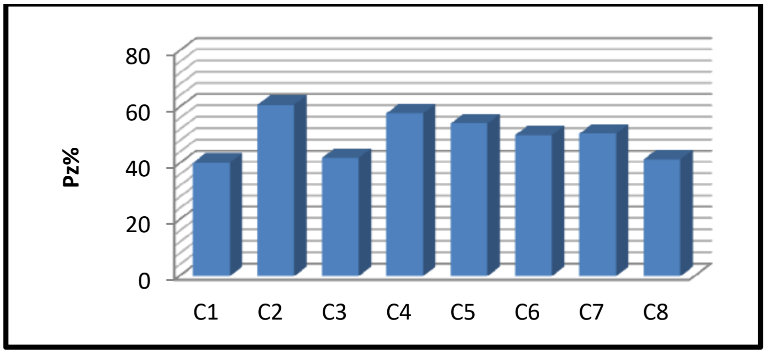

Figure 2. Porosity variation in types of textile materials intended for linings

The highest value of porosity is observed in the case of material 2, which is a non-woven used for the lining of the heel counter stiffener, respectively a material that is very resistant to wear, but also vapor permeability and moisture absorption capacity. Comparing material 7, which is an impregnated woven fabric with material 4, which is a fine yarn fabric, lower porosity values are observed for material 7. Material 1, which is a thermo-adhesive fabric used for doubling the shoe tops, has the lowest porosity value in order to avoid plastic deformations in the process of spatial formation.

In order to provide a suggestive illustration of the obtained data, the graph below (fig. 3) shows the porosity variation for all the studied materials. Thus, a comparative analysis of the values of this parameter can be made, starting from the structure and composition of each type of material.

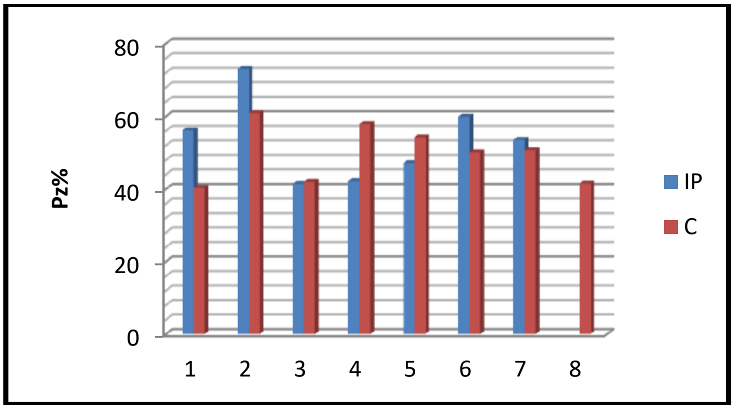

Figure 3. Porosity variation with different types of substitutes

CONCLUSIONS

After processing the experimental data, it is noticed that the porosity varies between 45 and 60%, i.e. within the limits indicated by the specialized literature which states that

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for the upper part of the footwear the limits are between 47 and 58%, and for the lower part the limits are between 29 and 47%.

The exception is material 7, which is actually a fabric enriched with rubber patterns (PVC, etc.) and which is hydrophobized; treatment actually applied on textile materials intended for footwear. The values for porosity are entered in the table above, to which benchmarks are associated for interpretation.

Making a comparison between leather and leather substitutes, following the analysis of the graphs obtained, a proximity of porosity values is observed for leather substitutes, intended for shoes uppers with chrome-tanned leather, a fact that justifies the tendency to use these days as much as possible footwear products made from leather substitutes, which have sanogenetic properties similar to natural leather.

It is therefore recommended that leather substitutes with porosity should be used in the manufacture of footwear products, so that they possess the ability to transmit and release moisture, maintaining a thermal transfer balance between the foot and the surrounding environment, taking into account the fact that footwear is a system composed of several layers of materials.

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