INFLUENCE OF THE HEAT BONDING ON AIR PERMEABILITY

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Usually, in footwear technology the upper materials are backed with heat bonding textile materials in order to increase the tensile and tear strength and the thermal resistance of the entire structure due to higher thickness. The paper studies the effects of the backing with heat bonding textiles on air permeability, an important comfort characteristic. The influence of the heat bonding with lining on the air permeability was studied using 5 types of bovine leather for upper materials and 4 types of knitted and woven fabrics for lining. The method to determine the air permeability is relatively simple and known. The air flow passing through the sample fixed on the device with the face upward is measured for certain values for the pressure difference. The conclusion drawn from the experiment is somewhat surprising: the air permeability increases with the thickness. This contradicts the general behaviour of textile structures, for which the air permeability decreases with thickness.

Keywords: footwear, air permeability, thermo-adhesive lining.

INTRODUCTION

The use of heat bonding is extending, due to the development of new materials with different physical, chemical and mechanical properties, as well as a large range of synthetic adhesives. The welding gives the structure an increased resistance to weather conditions and different chemical agents. This thermal joining was first called laminating.

Regardless of the position on the human body, the process requires a ground material and a material with thermal adhesive characteristics that is called reinforced lining. The upper material is bonded with the reinforced lining in order to obtain improved tensile and tear strength and, according to experimental data, also air permeability.

MATERIALS AND METHODS

The air permeability of a material or a system is defined as the amount of air passed over a surface under a certain pressure difference in a unit time. Generally, the pressure difference between layers is 0.2 to 20 mm water column.

The air permeability is calculated with the following relation:

$$P_a = \frac{V}{t \cdot A}, \ (\mathrm{m^3/m^2.min; l/m^2.s}) \tag{1}$$

Where:

V – volume of air passing through the sample under a preset difference of pressure (m^3; mm water column; l);

t – duration of air passing, (min, s);

A – sample surface (m^2).

The ratio between the volume of air V (m^3 or litres) and the time when the air flows through the material t (minutes or seconds) defines the air flow q (l/h).

The influence of the heat bonding with lining on the air permeability was studied using 3 types of bovine leather for upper materials and 4 types of knitted and woven fabrics for lining, presented in Table 1.

Table 1. Materials

	Material	Code
Upper materials	Embossed leather	A3
	Box with corrected grain	A4
	Buff leather	A5
	Thermo-adhesive knitted fabric	C3
Linings	Thermo-adhesive knitted fabric	C5
	Thermo-adhesive woven fabric	C6
	Thermo-adhesive woven fabric	C9

The two materials, the upper and the lining were cut and then welded using a heat bonding press and then cut to sample size.

The parameters of bonding proccess are the temperature, between 140-160°C, 4 atm pressure and the time of pressing around 6 – 8 seconds. Those parameters are setted in according with the adhesive caracteristics and the finishing of leather surface. The adjustment of bonding parameters must be set in optimum limits, because otherwise can damage the color and even the structure of the leather.

It is important to have a perefect jointting structure between leather and reinforcement lining, flexible and also resistant. The unsoldering resistance should be between 0,3 – 0,5 N/mm^2.

The method to determine the air permeability is relatively simple and known. The air flow passing through the sample fixed on the device with the face upward is measured for certain values for the pressure difference. In this case, the air flow was measured for a pressure difference of 20 mm water column. For each material, the air permeability was measured three times.

RESULTS AND DISCUSSIONS

Table 2 presents the average values for the experimental data.

Table 2. Air permeability

Code	q (l/h)	A (cm^2)	P_{ai}=q/(6*A) (m^3/min.m^2)
A3	10	20	0.083333333
A3+C3	34	20	0.283333333
A3+C5	18	20	0.15
A3+C6	21	20	0.175
A3+C9	15	20	0.125
A4	3	20	0.025
A4+C3	28	20	0.233333333
A4+C5	11	20	0.091666667
A4+C6	15	20	0.125
A4+C9	8	20	0.066666667
A5	6	20	0.05
A5+C3	38	20	0.316666667
A5+C5	24	20	0.2
A5+C6	24	20	0,2
A5+C9	20	20	0,166666667

Generally, the materials used for leather products have low air permeability, but the values can be improved through heat bonding. Figures 1 to 3 present the variation of the air flow for different upper leather bonded or not with reinforced linings.

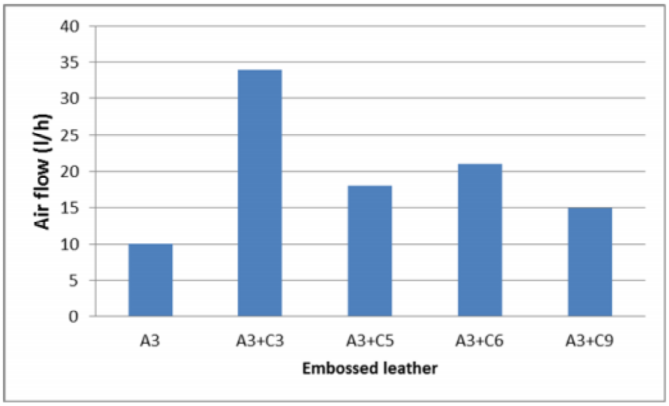

Figure 1. The air flow for embossed leather

The structures resulting from the embossed leather and different types of the reinforced lining present a major increased air flow. For structure A3+C9 the air flow was improve with 50% and in case of structure A3+C3 up to 240% more than A3.

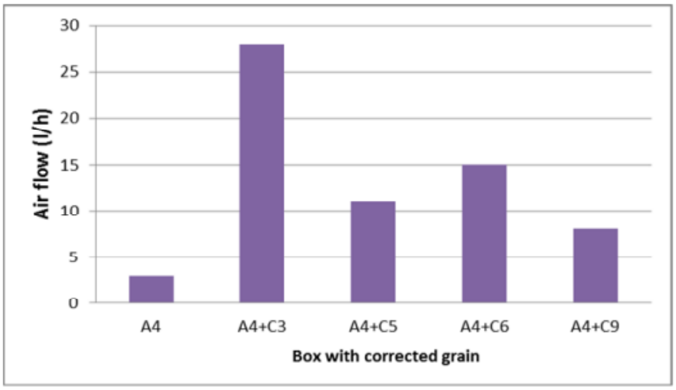

Figure 2. The air flow for box with corrected grain

Those structures obtain from box with corrected grain and reinforsed lining present an increase of the air flow with over 800% for A4+C3 and around 160% for A4+C9. For this upper structure was obtain the most important increase of the air permeability for all type of used linings.

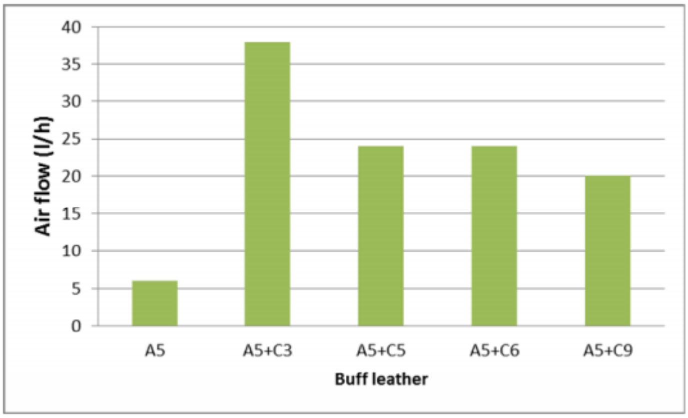

Figure 3. The air flow for buff leather

Like in previous two cases, the air flow is remarkable improved by the heat bonding. In this case, the structure A5+C3 has an air flow with over 500% more than A5 and with more than 200% for A5+C9.

The discussion was making only for the structures with biggest or the lowest increase of the air flow after heat bonded with reinforced lining: C3 has the best results and C9 has the worst results. This mean, the air permeability depends of type of lining (knitted or woven fabric), thickness and design of fabric.

In conclusion, the permeability of the leather variants is considerably improved by heat bonding with a jersey knitted fabric, thickness 0.735 mm.

The graphics presented in Figs. 4 to 6 and the regression equations in Table 3 show relation between air permeability and thickness of the structures.

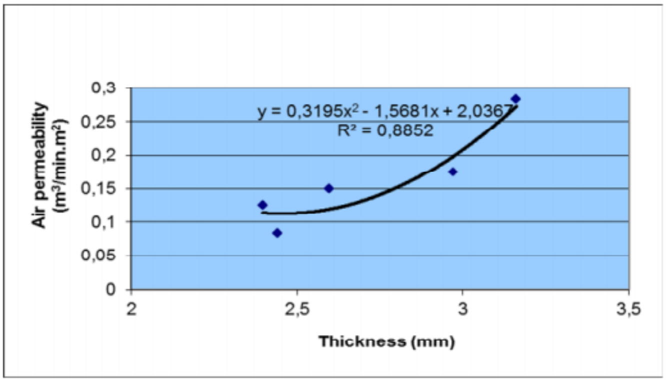

Figure 4. The air permeability for embossed leather

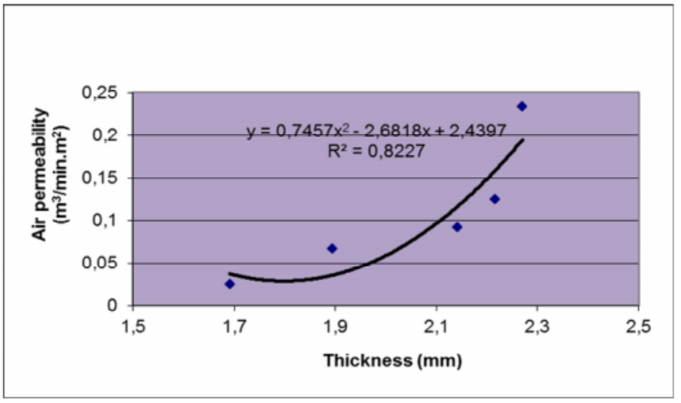

Figure 5. The air permeability for box with corrected grain

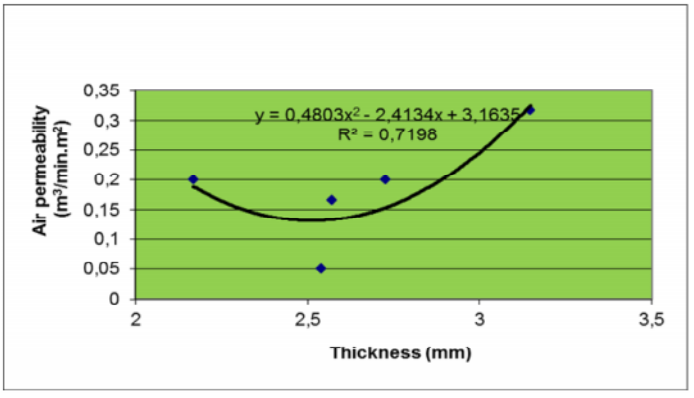

Figure 6. The air permeability for buff leather

The regression equations presented in Table 3 are polynomial functions and the values of the correlation coefficient are close to 1, indicating a strong correlation between the two parameters.

Table 3. Regression equation and correlation coefficient

Regression equation	Correlation
$y = 0.3195x^2 - 1.5681x + 2.0367$	$R^2 = 0.8852$
$y = 0.7457x^2 - 2.6818x + 2.4397$	$R^2 = 0.8227$
$y = 0.4803x^2 - 2.4134x + 3.1635$	$R^2 = 0.7198$

The conclusion is important and surprising: the air permeability increase with thickness and heat bonding linings. It is surprising because it is against of the low of the textile structures and against of the general opinion that the heat bonding afect in a negative way the permeability of the upper.

CONCLUSIONS

This paper investigates the effects of the backing with heat bonding textiles on air permeability and the results can be concluded there by:

1. When analysing the effects of the thermal treatment and pressure on the air permeability it can be concluded that the heat bonding of upper leather parts increase it.
2. A strong correlation was determined for all experimental variants between air permeability and the overall thickness.
3. The conclusion drawn from the experiment is somewhat surprising: the air permeability increases with the thickness. This contradicts the general behaviour of textile structures, for which the air permeability decreases with thickness. In this case, the thermal process associated with heat bonding causes the contraction of the entire structure and therefore increases porosity.

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