THERMAL INSULATION AND THERMAL CONTACT PROPERTIES OF UPHOLSTERED LEATHER FURNITURE IN WET STATE

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Abstract

Contemporary furniture should provide high level of the sensorial and thermal comfort to its users, both in dry state and after partial wetting due to the increased air humidity and sweating of the seated persons. In the paper, thermal resistance, thermal conductivity and thermal contact feeling (thermal absorbtivity) of 10 oxhide and 5 artificial leather samples used for the upholsted furniture were experimentally determined. The measurements involved the samples both in dry and wet state. It was found, that with the increased relative moisture of the samples, their thermal resistance decreases rapidly, and the feeling of coollnes increases.

Keywords: thermal comfort, leather, upholstery furniture

INTRODUCTION

Upholstered furniture is a common part of rooms, offices, bedrooms and public spaces. Seated people will feel comfortable, when the heat and moisture transfer between their body and the furniture will maintain thermal equilibrium of their bodies without sweating or shivering. Thus, the level of thermal and evaporation resistance of the furniture is very important. Part of this resistance levels depends on thermophysiological parameters of the fabrics creating the furniture surface. Surface of this furniture can be created by textile fabrics or by natural or artificial leather [1].

Important part of total comfort of the furniture is the sensorial comfort, which involves selected mechanical and thermal parameters of the used surface fabrics, namely:

- Friction + profile
- Moisture behaviour characteristics influencing the fabric / skin friction
- Thickness + compressibility
- Bending + shearing stiffness (at low and large deformations)
- Elasticity, tenacity
- Warm-cool feeling (transient heat transfer)

In this study, besides thermal resistance and thermal conductivity of the furniture fabrics, also the thermal-contact feeling properties of these fabrics were studied.

Humidity is another important aspect of thermal comfort [2]. A seated person will usually feel uncomfortable when humidity builds up at the skin's surface because moist skin creates increased friction coefficients, causing it to stick to clothing or chair upholstery and inhibiting the small movements required to shift weight off pressure points. Unfortunately, there are no papers available in the scientific literature, in which the effect of moisture on the selected thermal and sensorial properties of upholstery fabrics were systematically studied.

That is why the main objective of the paper is the experimental analysis of the effect of moisture on thermal resistance, thermal conductivity and thermal contact feeling (thermal absorbtivity) of 10 cowhide and 5 artificial leather samples used for the upholsted furniture. These properties were measured at several levels of their relative moisture U % related to their ultra-dry mass.

The used measuring instrument was the ALAMBETA, which enable non-destructive and fast testing of fabric samples in wet state also. The achieved results were statistically treated and the comfort properties of the studied samples were plotted as the function of their moisture. The samples which offered the highest thermal resistance and the dryest thermal contact feeleing were recommended for the production of the upholstered furniture with the best thermal comfort [3].

EXPERIMENTAL

The used instrument and tested properties

The ALAMBETA instrument used in this study measures thermal conductivity, thermal absorbtivity, thermal resis-tance and sample thickness. Its principle depends in mathematical processing of time course of heat flow passing through the tested fabric due to different temperatures of bottom measuring plate and measuring head. When the measuring head touches the fabric starts the measurement lasting several minutes only. Thus, reliable measurements on wet fabrics are possible, during which the sample moisture keeps almost constant [3].
Thermal conductivity coefficient λ of polymers is quite low, from 0,2 to 0,4 W/m.K, and that of textil-es ranges from 0,033 to 0,01 W/m.K. Thermal conductivity of steady air by 20°C is 0,026 W/m.K while thermal conductivity of water is 0,6 W/m.K, which is 25times more. That is why the water presence in textile materials is undesirable [4].
Thermal resistance R depends on fabric thickness h and thermal conductivity λ:

$$R = h/\lambda \; [m^2K/W] \qquad (1)$$

Thermal absorbtivity b of fabrics was introduced by Hes [5] to characterise thermal feeling during short contact of human skin with the fabric surface. The measured fabric was simplified into semi-infinite block with thermal capacity ρc [J/m³] and initial temperature t_2. Unsteady temperature field between the human skin (with temperature t_1) and fabric with respect to of boundary conditions offers a relationship, which enables to determine the heat flow q [W/m²] course passing through the fabric:

$$q = b\,(t_1 - t_2)/(\pi\tau)^{1/2}, \quad b = (\lambda\rho c)^{1/2} \; [Ws^{1/2}/m^2/K] \qquad (2)$$

where ρc [J/m³] is thermal capacity of the fabric and the term b presents its thermal absorbtivity. The higher is thermal absorbtivity of the fabric, the cooler is its feeling. In the textile praxis this parameter ranges from 20 $Ws^{1/2}/m^2K$ for fine webs to 600 $Ws^{1/2}/m^2K$ for heavy wet fabrics.

The tested samples

Figure 1: The new ALAMBETA tester

Figure 2: The upholstered furniture

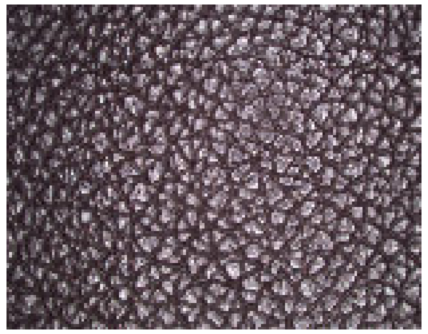

Figure 3: The cowhide surface

Tab. 1 Composition and properties of the tested samples (the cowhide and the laminated knitted fabric)

Sample	Composition	Substrate	Thickness [mm]	Thermal absorbitivity $Ws^{1/2}/(m^2K)$ i U = 10 %
1	Cowhide		0,54	356
2	Cowhide		0,77	270
3	Cowhide		0,86	275
4	Cowhide		0,89	276
5	Cowhide		1,01	291
6	Cowhide		1,12	277
7	Cowhide		1,19	306
8	Cowhide		1,47	297
9	Cowhide		1,55	284
10	Cowhide		1,63	281
11	PU coating 60%	PES knit 40%	0,67	315
12	PU coating 60%	PES knit 40%	0,79	297
13	PU coating 70%	PES knit 40%	1,05	420
14	PU coating 70%	PES knit 40%	1,13	390
15	PU coating 70%	PES knit 40%	1,18	374

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Results of measurements at contact pressure 200Pa and their evaluation

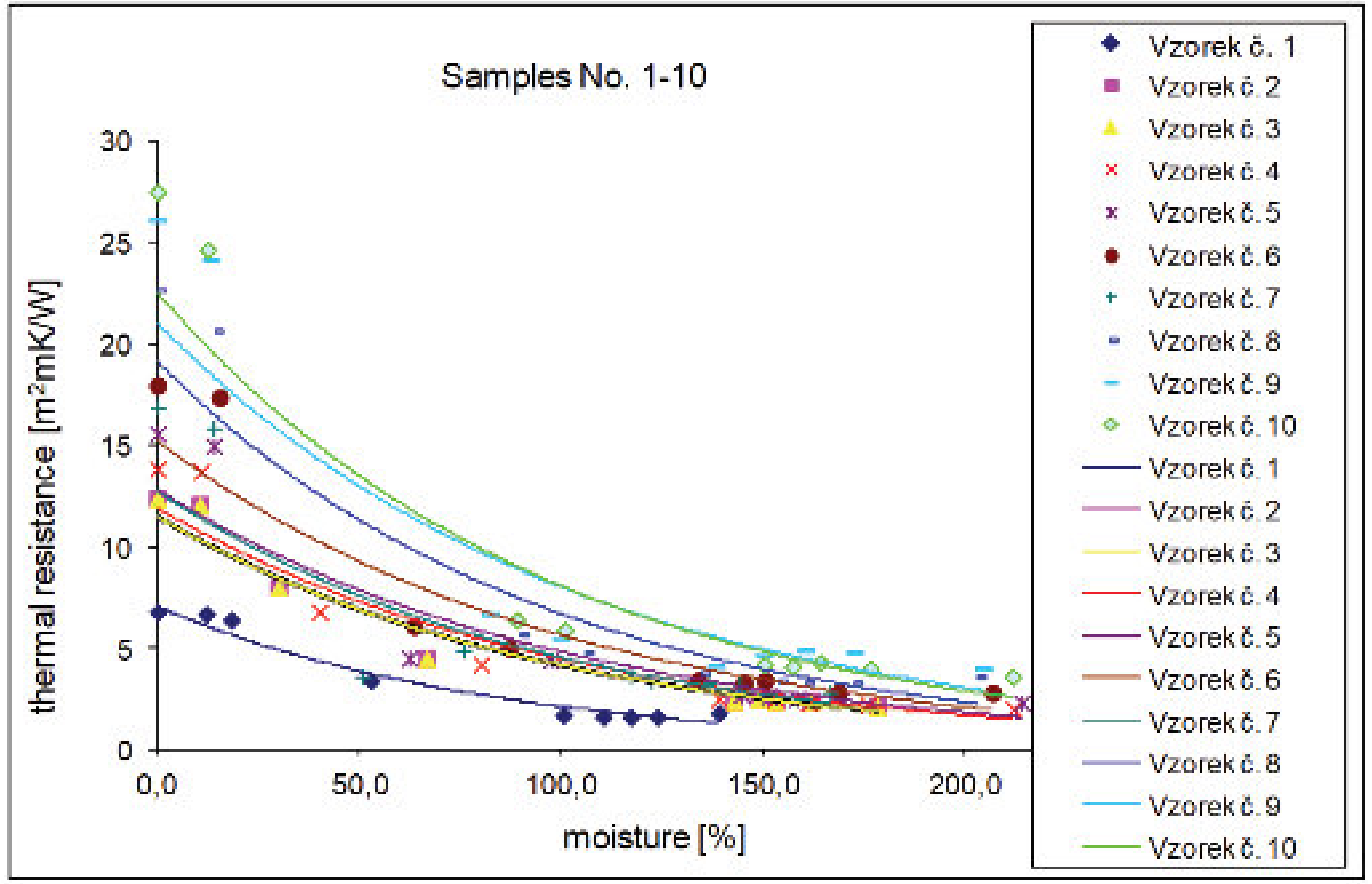


Figure 4: Thermal resistance levels determined on the wetted samples made of natural cowhide leather.

The resistance decrease with the increased moisture seems quite but this is just caused by the large moisture extension, as the natural leather is very hydrophilic. At the medium moisture levels thermal resistance of the natural leather surface of the furniture is still high. This feature makes the natural leather very comfortable. The Czech word „Vzorek“ means the „sample“.

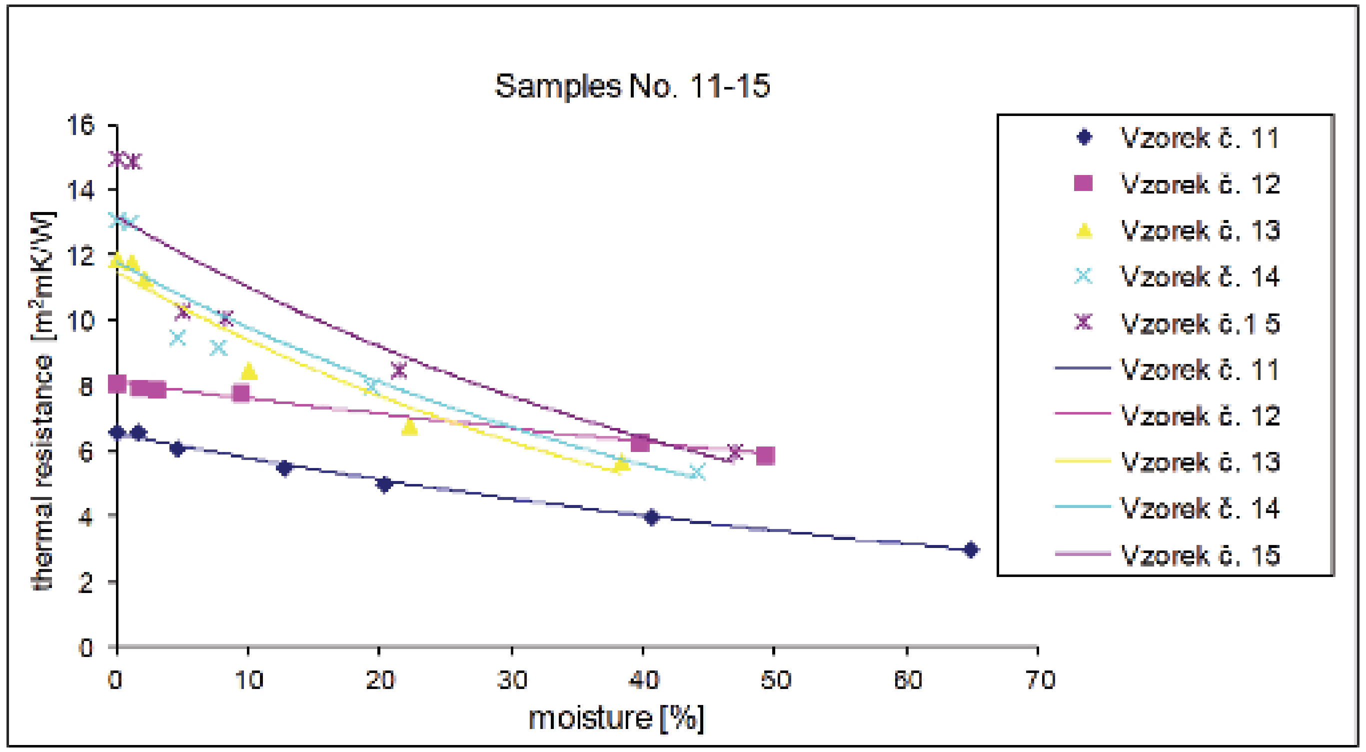
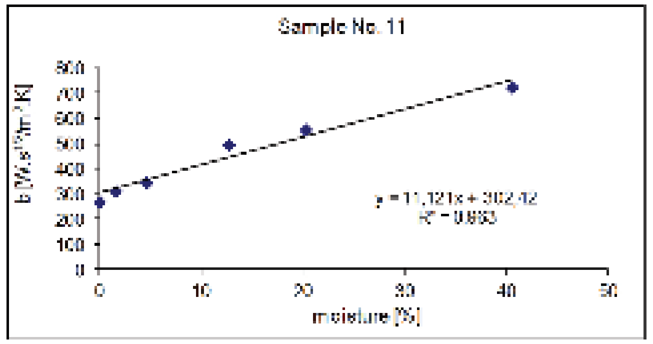


Figure 5: Thermal resistance levels determined on the wetted samples made of artificial leather.

The resis-ance decrease with the increased moisture seems relatively slow, but this is just caused by the low moisture extension, as the artificial leather is almost hydrophobic. This Czech word „Vzorek“ means again the „sample“.



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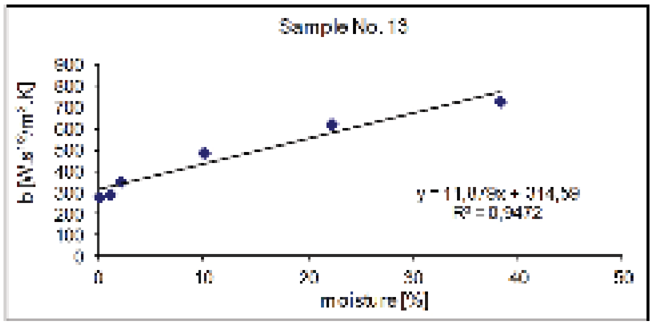

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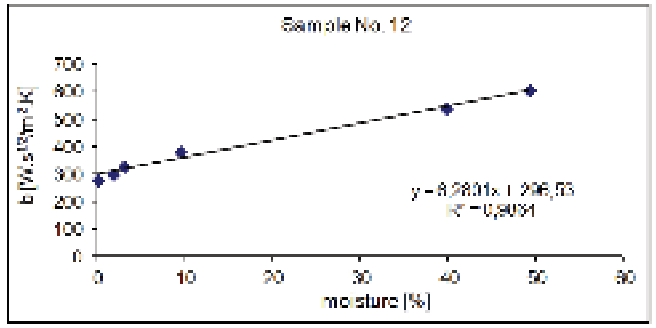

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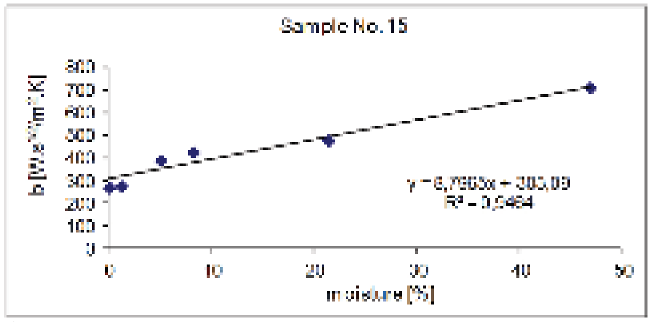


Figure 9.

Figures 6 - 9: Thermal absorbtivity levels determined on the wetted samples of artificial leather.

The cool feeling inrease with the increased moisture is quick despite small moisture extension, as the artificial leather is not very hydrophilic and the moisture is kept in the surface layers of the upholstery fabrics.

The cold feeling felt at at higher moisture levels makes the artificial leather quite discomfortable.

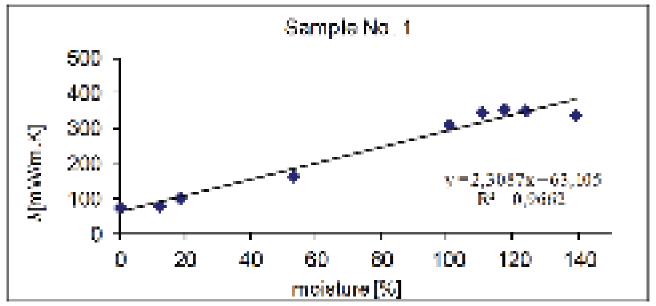
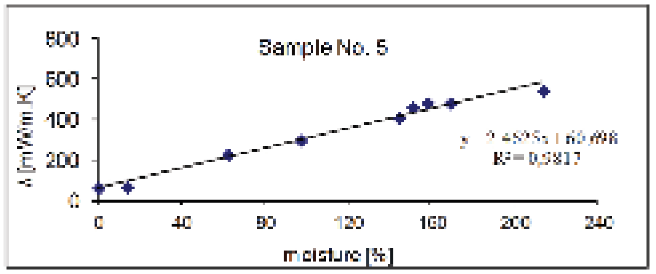


Figure 10.



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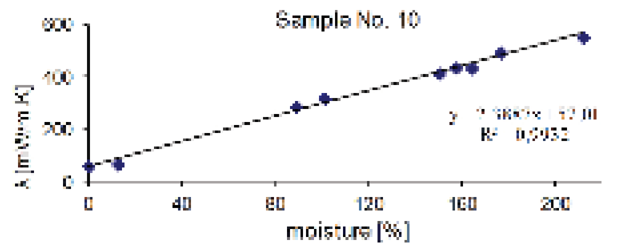

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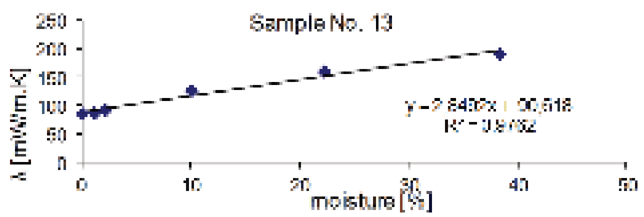

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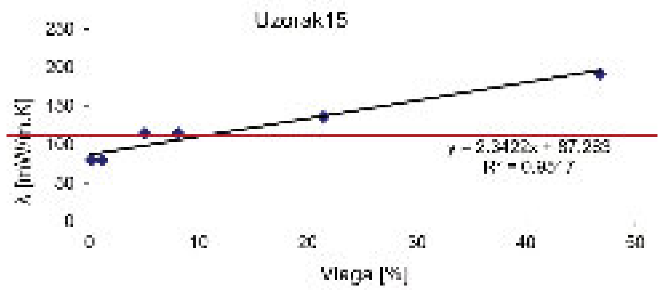

Figure 14.

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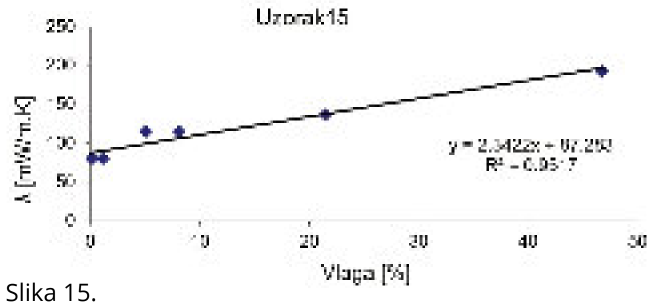

Slika 15.

Figures 10 - 15: Thermal conductivity λ determined on the wetted samples of natural (sample 1-10) and artificial leather.

Initial (dry) and medium levels of thermal conductivity of natural leather are lower. The thermal conductivity inrease with the artificial leather with the increased moisture is quick despite small moisture extension, as the artificial leather is quite hydrophobic. The initial low thermal resistance levels (as follows from the Eq. 1) can make the furniture covered by artificial leather in some extent discomfortable.

CONCLUSIONS

In the study, thermal resistance, thermal conductivity and thermal contact feeling (thermal absorbtivity) of 10 oxhide and 5 artificial leather samples used for the upholsted furniture were determined, both in dry and wet state. The measurement was based on the use of the fast testing ALAMBETA instrument. It was found, that with the increased relative moisture of the samples, their thermal resistance decreased rapidly, and the feeling of coolnes increases.

Samples made of natural leather exhibited always lower thermal conductivity and their thermal absorbivity was always warmer (drier) that that of artificial leather. The moisture absorbed at the levels typical for the practical use of the furniture resulted in slower decrease ot thermal resistance of the natural leather samples and slower increase of the cool feeling, if compared with the artificial leather. The warmest thermal contact feeling exhibited the sample No. 2.

Full analysis of the comfort properties of the upholstering fabrics would require also the determination of their water vapour permeability.

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