Paper C12

Physical properties of leathers for assessment of thermal comfort

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Introduction

Thermal comfort is the sense of satisfaction in relation with the climate condition of surrounding environment. The sense of comfort and discomfort does not depend only on temperature and relative humidity of the environment, but depends also on the human metabolism that activate processes of body thermal regulation able to determining different thermo-hygrometric sensation of the skin. This means that, at different external conditions, the same temperature is not always perceived as "comfortable".

When someone wear a footwear or a garment, thermal comfort depends on their capability to isolate body or to allow the thermo regulation mechanism. From a physical point of view, thermal comfort of materials is related to their own thermal conductivity and transpiration characteristics. Another important factor is its ability to reflect solar radiations.

The aim of this work is a preliminary identification of comfort temperature range of the skin in relation of environmental temperature in footwear wearing. The scope is the identification of physical parameters and values that can allow the definition of "thermal comfortable leather" before the production of leather goods.

Being the thermo-hygrometric sensation depending on environmental air velocity, radiant energy, body activity, clothing and psychological factors too, comfortable temperatures were measured supposing equal to zero the air flow and radiant energy on people in static activities.

Materials and methods

Thermal comfort ranges were determined using thermal sensors inside two different footwear wear by three different individuals. The two footwear were unlined, having the same polymeric sole and constituted by uppers having different thermal conductivity, water vapour permeability and water vapour transmission rate. The first one was characterized by very high thermal and vapour transpiration, the second one by very low thermal and perspiration properties. The different values of inner temperature at defined external temperatures were related to the sense of comfort or discomfort of the individuals.

Thermal conductivity (or insulation) of upper leathers in steady state conditions, that is the leather capability to dissipate heat, was determined in accordance with ISO 17705 (EN 13521).

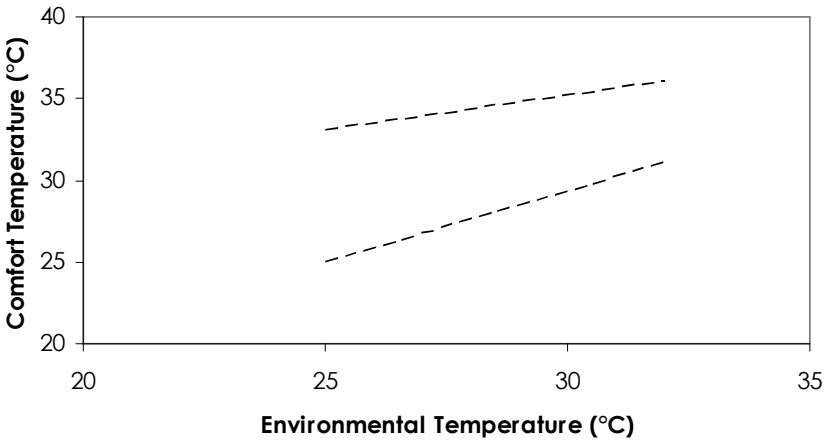
Transpiration properties of leathers were determined measuring the water vapour permeability (WVP), in accordance with EN ISO 14268, and the water vapour transmission rate (WVTR) in accordance with UNI 4818-26 (values expressed in $mg/cm^2/h$).

The properties of reflection IR frequencies of solar radiation were detected measuring the percentage reflectance at 900 nm in accordance with a draft test method proposed to CEN TC 289, using a LAMBDA 35 Spectrophometric System coupled with Integrating Sphere.

Results and discussion

The thermal comfort temperature range can be determined only assessing the real perception of discomfort of people in wearing footwear. Three different individuals provided their sensations in wearing two different shoes characterized by extreme values of permeability and thermal conductibility, varying the external temperature from 25°C to 32°C. The experiment was carried out

during static activities and without considering the effect of humidity. The results are represented in figure 1. The area between the curves represents the comfort temperature region.

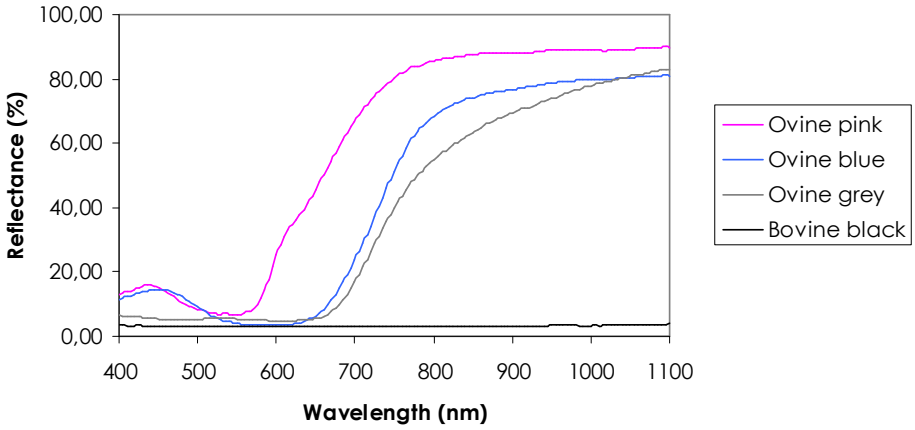


Two different leathers were analyzed for determining WVP, WVTR and thermal insulation. The first sample was an ovine chrome tanned leather (thickness 1,00 mm), the second one was a bovine chrome tanned leather (thickness 1,30 mm). The results are reported in the table above.

Sample	Determination	Test method	Unit	Value	Standard deviation
Ovine leather	WVP	EN ISO 14268	$mg/cm^2/h$	4,5	0,6
	WVTR	UNI 4818-26	$mg/cm^2/h$	2,6	0,4
	K	ISO 17075	$m^2°C/W$	$2,10 \times 10^{-2}$	$0,05 \times 10^{-2}$
Bovine leather	WVP	EN ISO 14268	$mg/cm^2/h$	1,5	0,2
	WVTR	UNI 4818-26	$mg/cm^2/h$	1,3	0,2
	K	ISO 17075	$m^2°C/W$	$2,22 \times 10^{-2}$	$0,04 \times 10^{-2}$

The two samples showed very similar values of thermal conductivity (K), but very different values of transpiration parameters (WVP and WVTR).
Two shoes were manufactured using the two different sample. The thermal comfort perception in a second wearing test showed the discomfort in using the shoe with bovine upper (inner temperature 36,4°C) and no discomfort using the footwear with ovine upper (inner temperature 33,7°C). These are preliminary data and further investigation is needed.
Looking to the sample characteristics, the ovine leather seems more comfortable due to its better properties to dissipate heat by a vapour flow. This consideration is probably related to the higher value of relative humidity inside the bovine upper that determines a higher perceived temperature.

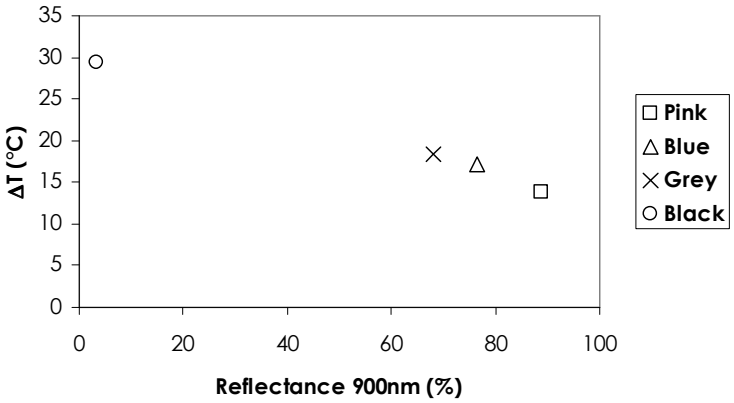
In this study, the influence of solar radiation in the thermal performances of leathers was examined too. Three ovine semi-aniline leathers, different only in colour (pink, blue and dark grey) and one black semi-aniline bovine leather were exposed to the sun radiation for a period of one hour. Heating of the surfaces during the solar exposition is connected to their grade of absorption of infrared wavelengths; less is the reflectance of IR frequencies and more intense is the heating of the surface.
The IR reflectance were determined using a spectrophotometer and the quantification of solar radiation absorbed was assessed at 900 nm. In figure 2 are showed the spectra of samples analized.



The percentage reflectance values at 900 nm of the 4 samples are reported in the table above.

Sample	Reflectance at 900 nm (%)	Standard Deviations (%)
Pink	88,7	3,4
Blue	76,6	3,1
Grey	68,0	4,2
Black	3,4	0,1

Samples were exposed for 1 hour to solar radiation having an intensity of 161 klux ± 3 klux. Surface temperature of the samples were measured before the exposition and after 1 hour. In figure 3 is shown the relation between IR reflection and relative increasing of surface temperature.



As expected, samples characterized by higher IR percentage reflectance, show a lower increasing of surface temperature. From the point of view of thermal comfort, the experiment pointed out that the item colour affects its temperature and thus determines the increasing of temperature of the inner surface in contact with skin, because of the thermal conductivity of the material.

Conclusions

Thermal comfort of leather could be defined before the production of leather goods. In this work thermal characteristics were analyzed in terms of leather conductivity, transpiration properties and solar reflection and the comfort was assessed by wearing test, correlating the results to the characteristics of materials.

In order to define "thermal comfort", further tests will be carried out to determine:

- the comfort temperature range of the skin in relation of environmental temperature in footwear wearing;
- the relationship between perceived temperature and relative humidity;
- the correlation of the leather thermal characteristics with the perceived temperature;