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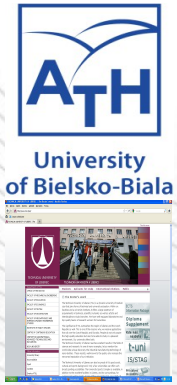
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Analysis of Changes in the Thermal Comfort Properties of Nomex Fabrics Due to Salt Water Sorption



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OPTIS PRO FT

PROJEKT OPTIS PRO FT, reg. č.: CZ.1.07/2.2.00/28.0312 JE SPOLUFINANCOVÁN EVROPSKÝM SOCIÁLNÍM FONDEM A STÁTNÍM ROZPOČTEM ČESKÉ REPUBLIKY

1. Introduction

2. Experimental Materials

3. Experimental Devices

4. Research Program

5. Results and Discussion

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1.Introduction

Thermal comfort is defined as that condition of mind which expresses satisfaction with the thermal environment (ASHRAE's defination Fanger 1982).

Thermal comfort implies the maintenance of the body temperature within relatively small limits (average skin temperature 32-340C).
Under the conditions where the thermal comfort cannot be achieved by the human body's own ability (f. e. body temperature regulation), such as very cold or hot weather, **CLOTHING** must be worn to support its temperature regulation by:

- resisting,
- facilitating the heat exchange between the human body and the environment.

In the dry state, the majority of semipermeable materials, which are used in barrier garment usually guarantee a satisfactory level of thermal properties

1.Introduction

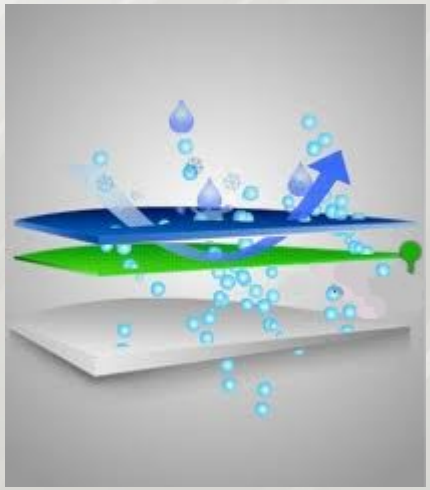
The protective clothing are often used in wet state:

- ✓ due to sweat sorption,
- ✓ because of the effect of rainy climate

influence their thermo-physiological comfort.

The final thermophysiological comfort is given by two principal components:

- ✓ thermal resistance in wet state,
- ✓ the active cooling resulting from: the moisture evaporation from the skin and passing through the garment and from direct evaporation of sweat from the fabric surface



1.Introduction

An equally important issue is the composition of moisture.

Sweat is a clear, colourless liquid secreted by the sweat glands. It consists primarily of water (~98%) and salt, fats, urea, lactic acid, carbohydrates, minerals.
An indication of the minerals content is sodium (0.9g/l), potassium (0.2g/l), calcium (0.015g/l), magnesium (0.0013 g/l)

Environment - the most extreme is sea and ocean environment. The characteristic feature of the sea is salinity. The vast majority of seawater has a salinity of between 3.0% and 3.8%, but seawater is not uniformly throughout the world.

2. Experimental Materials

Table 1. Specifications of the tested fabrics.

No	Name of fabrics	Type	Raw material	Weight, gm-2	Thick., mm	Density of threads, dm-1	
						warp	weft
1	Nomex Comfort 190	2/1 twill	93% Nomex / 5% Kevlar/ 2% carbon fibres	190	0.56	350	280
2	Nomex Comfort 220	2/1 twill	93% Nomex / 5% Kevlar/ 2% carbon fibres	220	0.54	371	279
3	Nomex Comfort NX Delta	2/1 twill	93% Nomex / 5% Kevlar/ 2% carbon fibres	265	0.52	290	200
4	Nomex Comfort FC Navy	2/1 twill	100% Nomex	220	0.62	290	250

3. Experimental Devices

Computer-controlled instrument ALAMBETA for fast measurement of thermal insulation and thermal-contact properties of compressible materials like textile fabrics

FIGURE 2. Computer – controlled instrument ALAMBETA for fast measurement of thermal insulation and thermal – contact properties of textile fabrics.

The research were carried on the fast measuring PC evaluated instruments ALAMBETA, which provide reliable non-destructive measurement of thermal properties.

By means of this instrument thermal conductivity and thermal resistance of selected Nomex fabrics in dry and wet state were determined.

Moreover, the effect of salinity of real sweat or see water was simulated, by adding 1%, 2% and 3% of sodium chloride into the testing liquid (distilled water).

4. Reaserch Program

Thermal properties of fabrics:

- **Thermal conductivity coefficient (λ)** presents the amount of heat, which passes from 1m2 area of material through the distance 1m within 1s and create the temperature difference 1K.

Values of selected examples of thermal conductivity coefficient:

- textile structures – 0.033 – 0.01 W/mK
- air in temp. 200C – 0.026 W/mK
- water – 0.6 W/mK
- salt - 6.5 W/mK
- sea water at salinity 35 g/kg and atmospheric pressure - 0.596 W/mK

- **Thermal resistance (R)** is a measure of a material's ability to resist heat transfer. It depends on fabric thickness **h** [mm] and thermal conductivity **λ** [W/mK]:

$$R = h/\lambda \ [m2K/W] \qquad (1)$$

4. Reaserch Program

The fabrics were tested in various states of moisture content:

1. **-"ultra-dry" state**
2. **- normal state**
3. **- in various of wet states**

4 types of bath:

- water without salt
- aqueous salt solutions, having respectively a concentration of 1%, 2% and 3% of sodium chloride.

The percent of samplesmoisture content was determined by the equation:

$$U = [(mw - ms)/ ms]*100\ [\%] \qquad (2)$$

5. Results and Discussion

The hypothesis of the research was the follows:

The liquid water in wet fabric structure creates the partially continuous film, which interfered with heat transfer.

5. Results and Discussion

Thermal properties of Nomex fabrics in wet state.

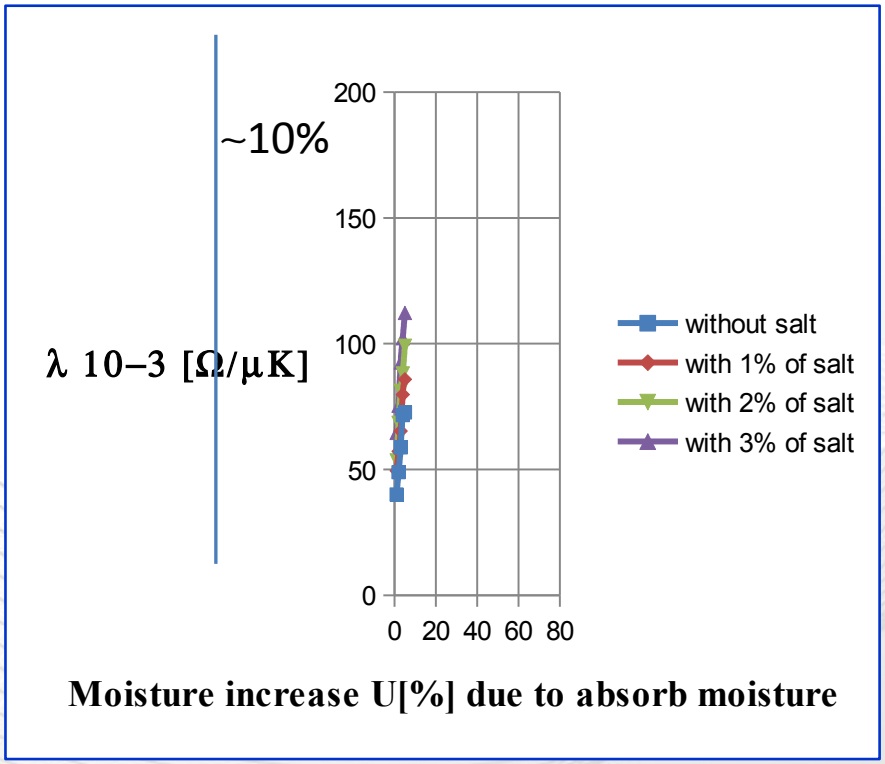


Figure 1. Effect of moisture content on thermal conductivity of the Nomex Comfort 220 fabric.

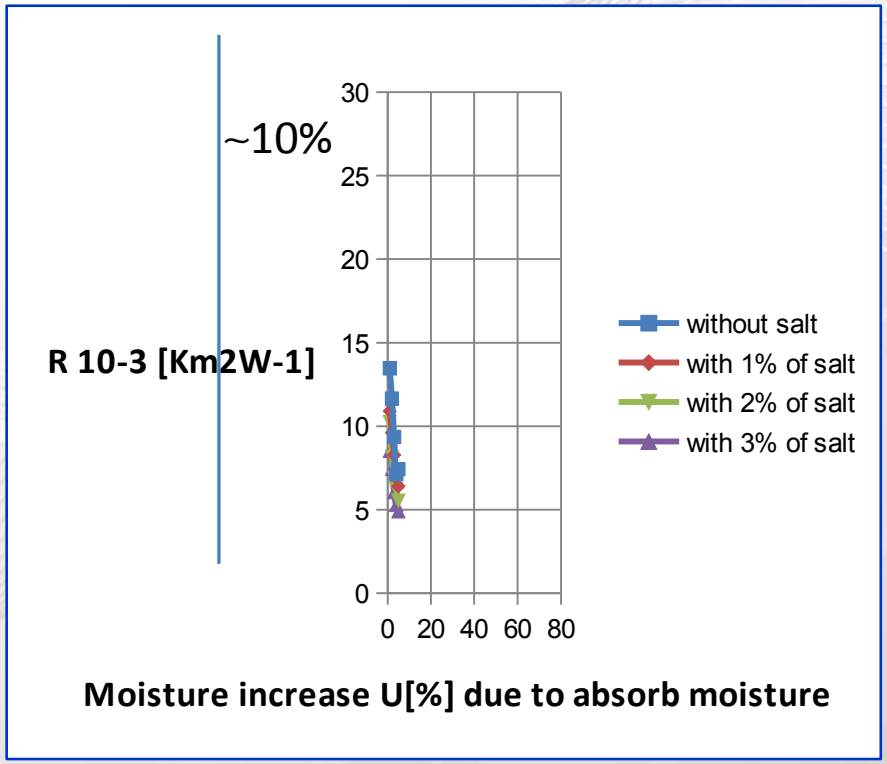


Figure 2. Effect of moisture content on thermal resistance of the Nomex Comfort 220 fabric.

5. Results and Discussion

Thermal properties of Nomex fabrics in wet state.

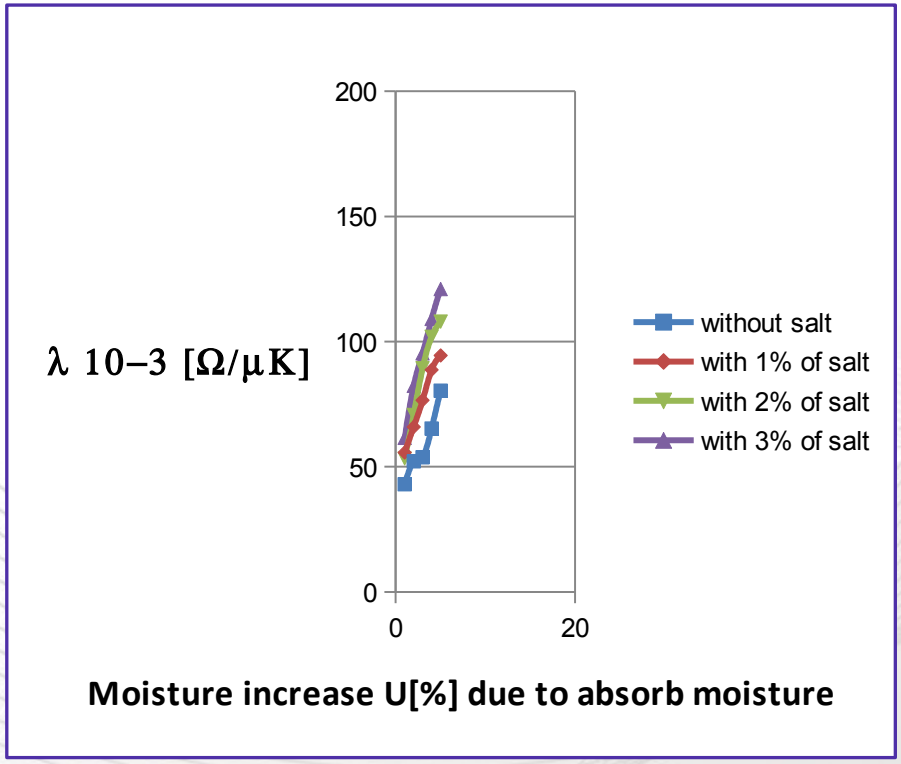


Figure 3. Effect of moisture content on thermal conductivity of Nomex Comfort FC Navy fabric

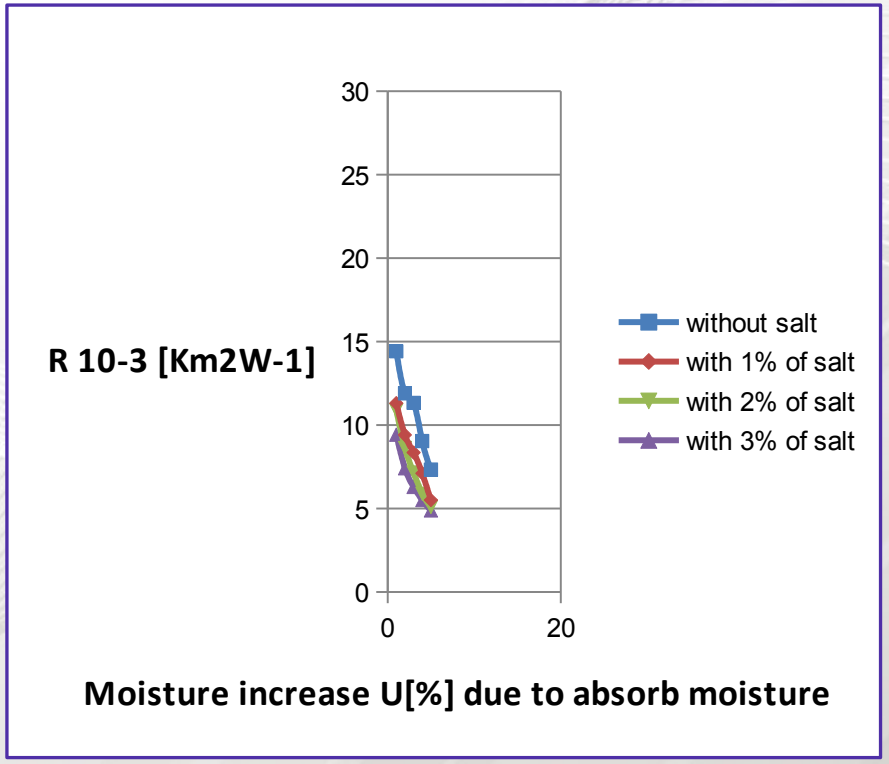


Figure 4. Effect of moisture content on thermal resistance of Nomex Comfort FC Navy fabric

5. Results and Discussion

Thermal conductivity of Nomex fabrics of 30% moisture content.

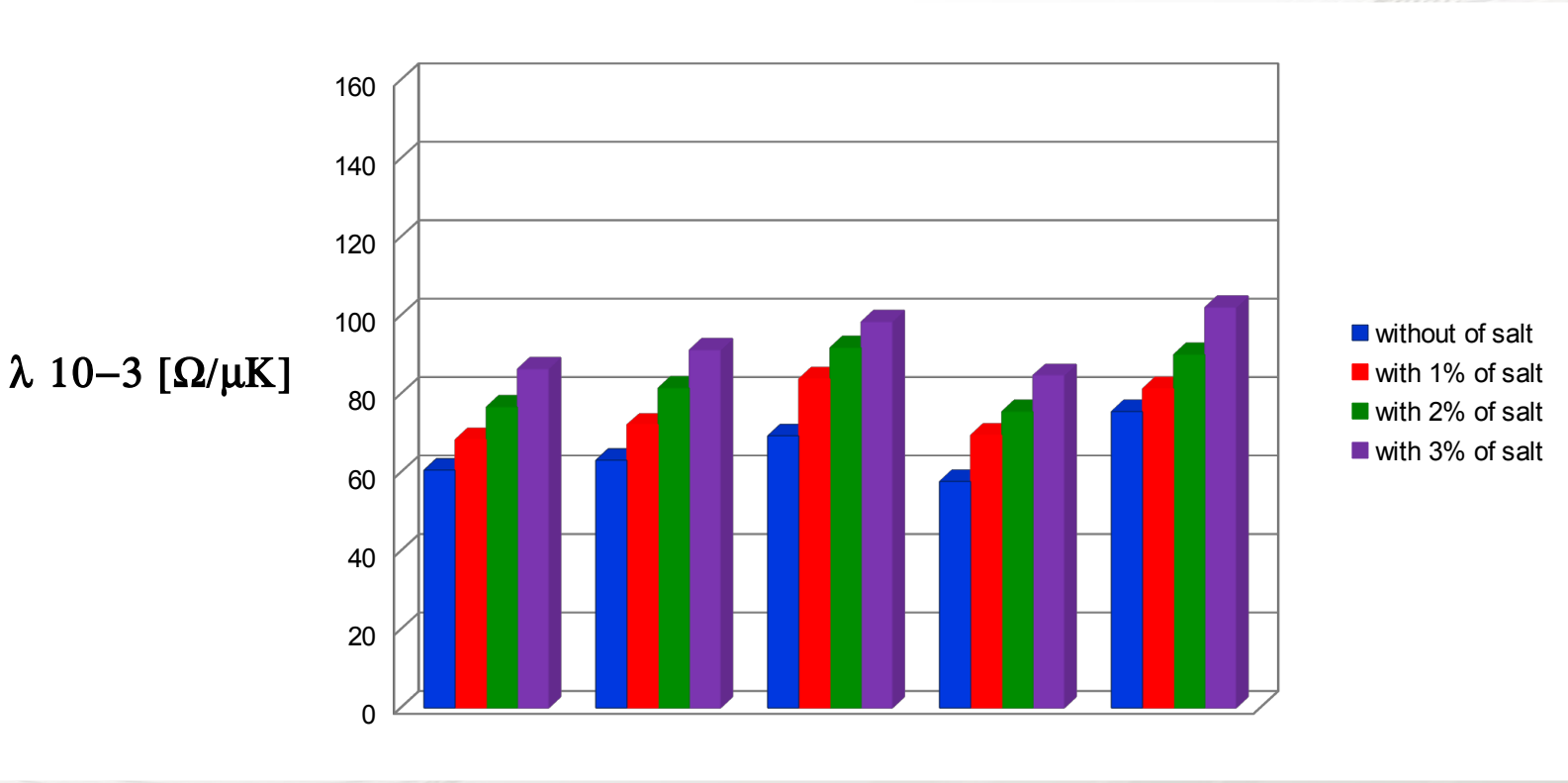


Figure 5. Thermal conductivity of all tested Nomex fabrics of 30% moisture content.

5. Results and Discussion

Thermal conductivity of Nomex fabrics of 50% moisture content.

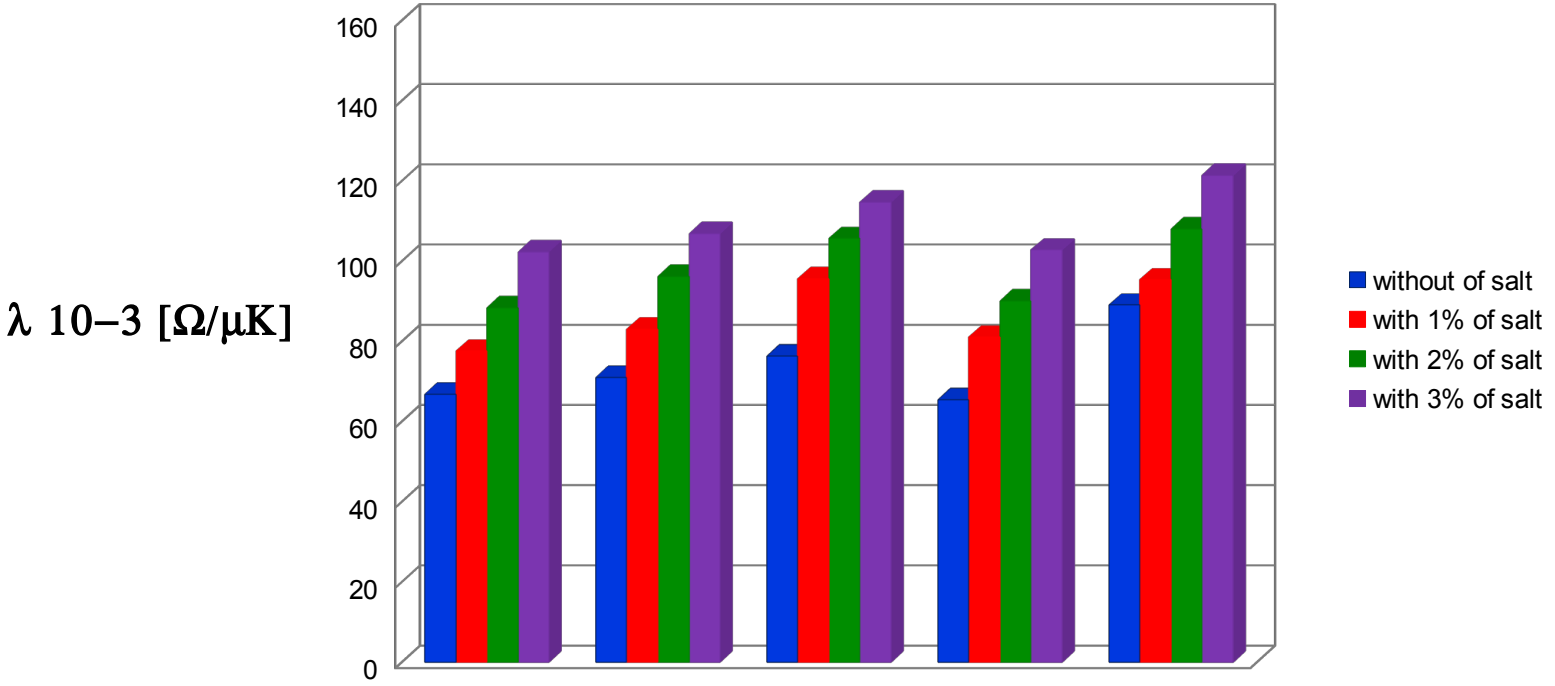


Figure 6. Thermal conductivity of all tested Nomex fabrics of 50% moisture content.

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1.Results and Discussion

Impact of moisture content and salt concentration on the thermal conductivity

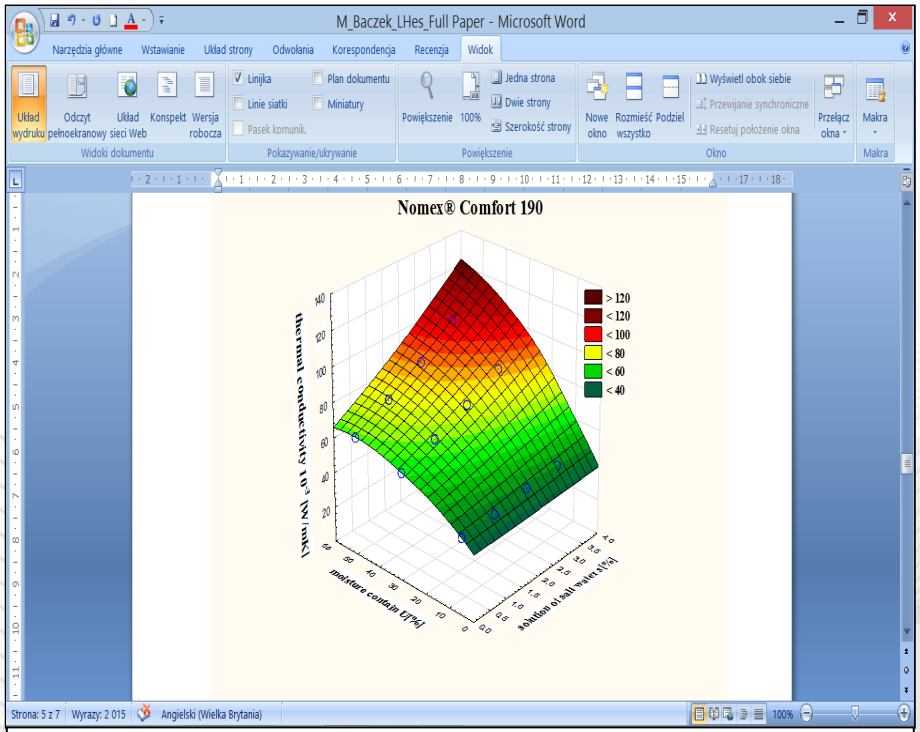

Figure 7. Effect of moisture content and the concentration of the salt solution on thermal conductivity of Nomex Comfort 190 fabric (Sample 1).

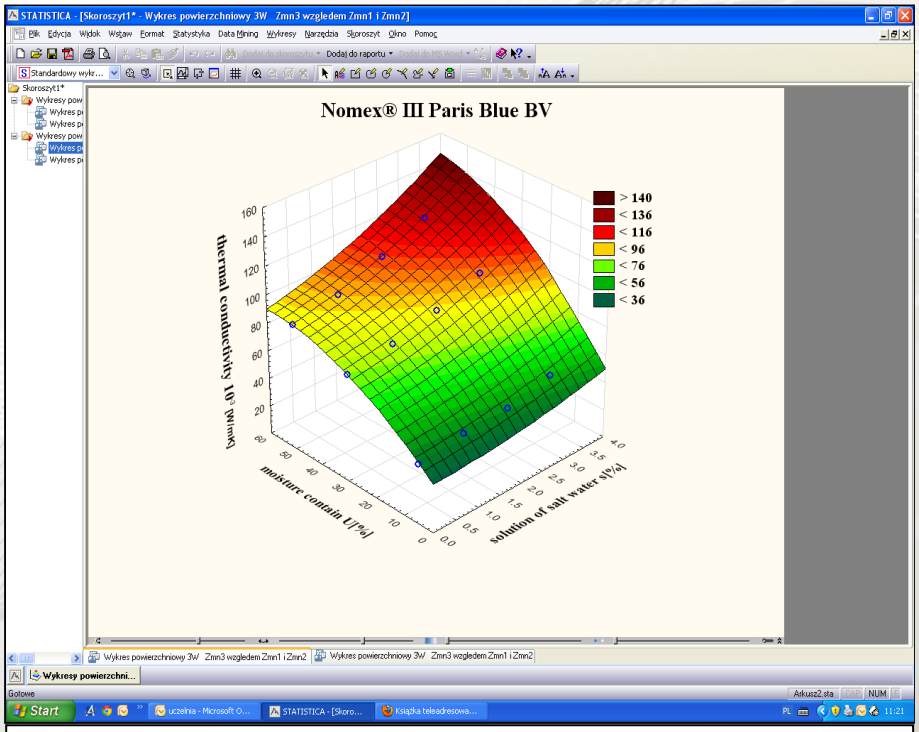

Figure 8. Effect of moisture content and the concentration of the salt solution on thermal conductivity of Nomex Comfort FC Navy fabric (Sample 4)

6. Concusions

With the increase in moisture content of the tested Nomex fabrics the thermal insulation properties significantly decreased. At 50% moisture content the thermal conductivity increased by an average of 65%, while the thermal resistance decreased by 40%.

The increasing percentage of the aqueous solutions of sodium chloride causes the increase of thermal conductivity of wetted fabrics and reduce substantially their thermal resistance. At 3% concentration of the water solution the thermal conductivity of the wet fabric increased by an average of 50% in relation to the fabric soaked in pure water and 70% in relation to of the dry fabrics.

This problem can by further complicated by the fact that salt water after drying clothing without previous washing can crystallize inside the fabric and seal the pores by salt. And this has a negative impact not only on the thermal insulation of the clothing, but also on the water vapor permeability.

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Thank You For Your Attention!

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