The influence of unconventional assembly techniques on the comfort indicators of waterproof materials

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ABSTRACT – REZUMAT

The influence of unconventional assembly techniques on the comfort indicators of waterproof materials

The present paper aims to highlight the correlations between the comfort indicators of waterproof cotton-based fabrics, and the specific parameters of unconventional assembly technology. The materials considered include layers of Gore-Tex film, serving as substitutes for waterproof materials, intended to manufacture outerwear products such as protective equipment (jackets and overalls), which are breathable waterproof membranes. The comfort indicator values were obtained through standardised methods, and data processing and representation in two-dimensional (2D) and three-dimensional (3D) systems using correlation/graphing methods were carried out in Excel software, and using Jandel Table Curve 3D v2. Although experimental research can be extended to include specific functions related to durability indicators, this study focused theoretically and experimentally on how the variation in temperature of the low-pressure hot air jet can lead to changes in the vaporization coefficient, air permeability index, and thermal conductivity coefficient. The relationship between the comfort indicator values (thermal conductivity coefficient, air permeability index, and vapour permeability coefficient) of the considered materials and the treatment parameters of the installation (pressure, temperature, velocity) is expressed through statistically adequate mathematical models, highlighted by a correlation coefficient R = 0.983, with significance certified by the Fischer test. The study of comfort indicators was conducted under optimized treatment parameters, ensuring durability and presentation value functions in the treatment zone remain unchanged compared to those of the base materials.

Keywords: *functional textiles, vapour permeability, air permeability, thermal conductivity, correlation method*

Influența tehnologiilor neconvenționale de asamblare asupra indicatorilor de confort a materialelor impermeabile

Lucrarea și-a propus să evidențieze corelațiile dintre indicatorii de confort ai țesăturilor impermeabile realizate din fire tip bumbac și parametrii specifici tehnologiei neconvenționale de asamblare. Materialele studiate au în componență straturi cu pelicula Gore-Tex, care sunt membrane impermeabile respirabile, destinate confecționării produselor de îmbrăcăminte exterioară, și anume echipamente de protecție (jachete și salopete). Valorile indicatorilor de confort au fost obținute prin metode standardizate, iar prelucrarea și reprezentarea datelor în sistemele 2-D bidimensional și 3-D tridimensional prin metoda corelației/grafică a fost realizată utilizând aplicația Jandel TableCurve 3D v2 și Excel. Deși cercetările experimentale pot fi extinse și asupra unor funcții specifice indicatorilor de durabilitate și valoare de prezentare, în cadrul acestui studiu s-a analizat din punct de vedere teoretic și experimental modul în care variația temperaturii jetului de aer cald de joasă presiune poate duce la modificarea coeficientului de vaporizare, indicelui de permeabilitate la aer și a coeficientului de conductivitate termică. Dependența dintre valorile indicatorilor de confort (coeficientul de conductivitate termică, indicele de permeabilitate la aer și coeficientul de permeabilitate la vapori) a materialelor studiate și parametrii de tratare a instalației (presiune, temperatură, viteză), se concretizează prin modele matematice adecvate din punct de vedere statistic, evidențiate de coeficientul de corelație R = 0,983, iar semnificația fiind certificată de testul Ficher. Studiul indicatorilor de confort s-a efectuat în condițiile optimizării parametrilor de tratare, în sensul că sunt garantate în aceste condiții funcțiile de durabilitate și valoarea de prezentare în zona de tratare, funcții care nu se modifică față de cele ale materialelor de bază.

Cuvinte-cheie*: textile funcționale, permeabilitate la vapori, permeabilitate la aer, conductivitate termică, metoda corelației*

INTRODUCTION

The paradigm shift from the traditional approach of producing textiles with the highest material efficiency at the lowest costs to one that assigns economic value to the elimination of hazardous chemical emissions can be seen, for example, in the large textile segment of “functional textiles” [1–3]. Modem textile industry is influenced both by consumers' lifestyles and by novel materials. Functional textiles in contrast to e.g., fashion clothing, are designed to contain certain technical functions [4–6]. Outdoor, sports and personal protective garments are based on functional textiles. Nevertheless, textile function can also be associated with fashion since "branding" and the desire to "wear what the experts wear" are likely to influence consumers' purchasing behaviour [7–9].

Gore-Tex is a breathable waterproof fabric membrane found in performance and technical clothing items like ski jackets, raincoats, hiking boots, and work gloves [10–13]. Functional textiles have opened up a new world of possibilities in a variety of fields [14]. Waterproof breathable fabrics are designed for use in garments that protect from the weather that is from wind, rain and loss of body heat. Different properties of clothing also affect thermal comfort, such as fabric design with a certain structure, fibre composition, and porosity, i.e. [15–19]. Correlation is a statistical method used to assess a possible linear association between two continuous variables. The first step in analysing correlations between two quantitative variables should be to look at a scatter plot, to discern whether there is a gradual variability between the sets of variables, whether this variation is monotonic (predominantly increasing or decreasing), if it follows a proportional tendency (linear), and whether the underlying distribution of the data is normal [20–23]. Different combinations of these premises indicate a need for different techniques for correlation analysis.

MATERIALS AND METHODS

The studied material comprises layers of fabrics with Gore-Tex film, obtained through finishing processes with directed physical treatment in cold plasma with air, followed by chemical treatment with a 9% concentration solution of dimethylformamide polyester or polyurethane, then wringing, drying at 65°C for one hour, and finally at 80°C for three hours. The justification for using Gore-Tex films in products serving as substitutes for waterproof materials is aimed at manufacturing outerwear garments, specifically protective equipment such as jackets and overalls. The fabric is characterized by the following structural and visual features: fibre composition (65% Polyester + 35% Cotton), balanced in fineness (Nm warp 68/2=Nm weft 68/2), and with a Plain weave.

Regarding the choice of laminate, it is specified that fabric laminate and three-layer laminate are preferred for functional clothing items such as workwear and protective equipment. Insert laminate and lining laminate offer more freedom in choosing the fabric and designing the pattern, making them particularly attractive for sportswear and modern leisurewear.

Generally, after sewing, the corresponding surface along the assembly line is sealed, and for this purpose, the sewing allowances must be located on the membrane side. This applies to fabric laminate, lining laminate, and three-layer laminate. To ensure proper coverage with the sealing tape, sewing allowances should not exceed 0.5 cm in width.

In the case of insert laminate, the membrane part is processed onto the membrane side, so that the seam allowances face the back of the laminate.

Consequently, in this case, flattening the seam allowances is not necessary. If the thermal insulation layer has low air permeability, wind-resistant lining may not be required. The wind-resistant lining layer can be replaced with a climatic membrane, waterproof even under repeated stress conditions, protecting against rain and snow. The climatic membrane is breathable, thus exhibiting vapour permeability within acceptable limits. It is crucial that after sewing, especially for products with special purposes, joints with secondary materials (sealing tape) should be sealed, which is essentially a joining process through convection, where the heating agent is a low-pressure gas stream, most commonly compressed air [24–28].

At the core of this technology lies the process of thermos-adhesive welding, which is positioned at the boundary between heat bonding and welding. Waterproof seams are obtained in two stages:

- Assembly by sewing the product parts together.
- Applying the sealing tape along the assembly line.

This technology is specific to the manufacturing of waterproof clothing products or thermal protection gear made from materials with two or three layers. The sealing tape has a morphological and chemical structure adapted to each type of material, as presented in figure 1 for the three variants V1, V2, and V3, which include the following elements: 1 – coating polymer; 2 – hot-melt thermos-adhesive; 3 – fabric; 4 – paper backing.

Thus, the chemical structure of layer 1 is similar to or compatible with the coating polymer used to obtain the processed composite material, which is a condition for completing the welded joint. The thermos-adhesive 2 is thinly applied on the surface of polymer 1 and has a low softening temperature.

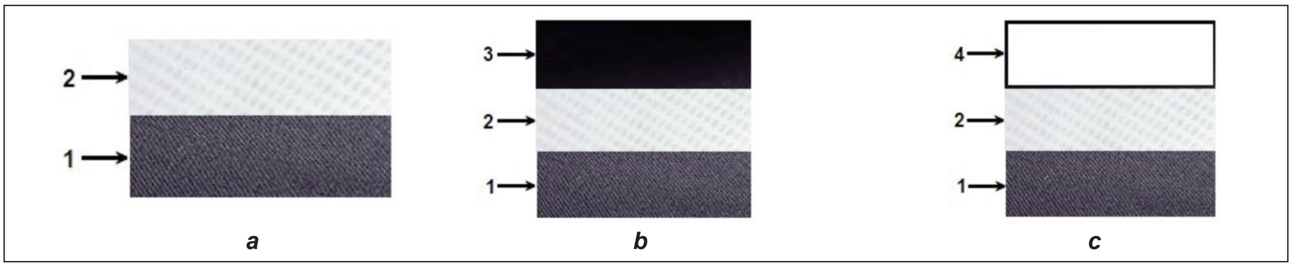

Fig. 1. Types of sealed tapes: *a* – Variant V1 – for 2L lamination; *b* – Variant V1 – for 3L lamination; *c* – Variant V3 – with siliconized paper backing

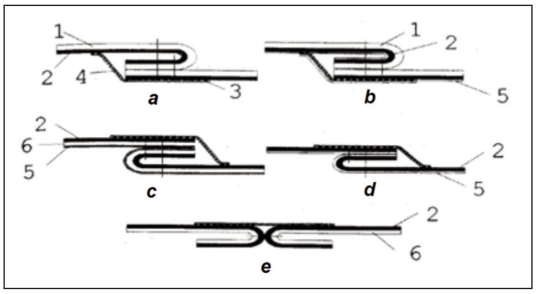

Fig. 2. Technological variants of sealing subassemblies: *a* – 2L laminate base material; *b* – 3L laminate base material; *c* – 2L laminate intermediate layer processed simultaneously with the lining layer; *d* – 2L laminated lining; *e* – 2L laminated intermediate layer

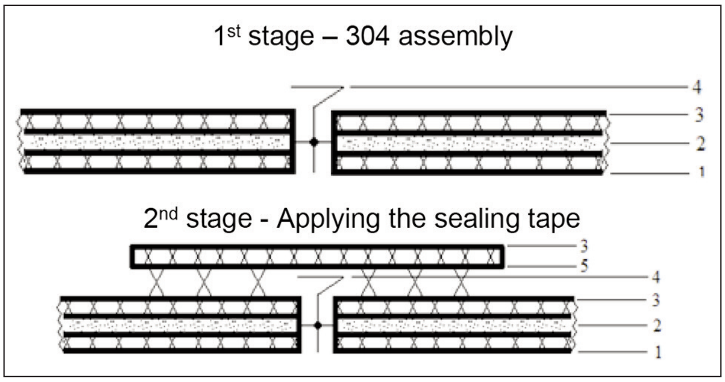

Fig. 3. Stages of obtaining sealed joints: *1* – base material; *2* – fabric or non-woven; *3* – polymer layer; *4* – stitching 304; *5* – thermo-adhesive film

In some cases, to avoid deformations that may occur during processing or transportation, an additional paper strip is attached as a support, which is removed after welding. The sequence of phases in the production process of sealed tapes consists of heating, pressing, and cooling. The technological parameters of the process are: the temperature of the air jet at the outlet of the heating system T (°C), the pressing force p (kPa), and the welding speed v (cm/min), which is equivalent to the tangential speed of the conveyor rollers. The technological variants of the sealing subassemblies, established based on the structure of the materials, are presented in figure 2.

Experimental research has been extended to assemblies similar to variant V3, but involving a different seam. Component elements are: 1 – textile support; 2 – coating polymer; 3 – thermos-adhesive; 4 – support polymer; 5 – lining; 6 – textile surface (fabric or non-woven) used as a support for the intermediate layer.

Additionally, in figure 3, the adherence to the two stages of obtaining sealed joints is highlighted, where the base material consists of layers 1, 2, and 3.

For the studied materials, comfort indicators are assessed by: moisture transfer in the vapor state (vapour permeability, P_v (g) and vapour permeability coefficient, μ (g/m^{2}h), according to ISO 11092); air transfer (air permeability P_a (m^3/min·m^2) and air permeability index I (kg/m^{2}h), according to ASTM D 737-04 standard); and heat transfer (thermal conductivity coefficient λ (kcal/mh°C), according to ISO 11092). The comfort indicator values of the studied materials were obtained through standardized methods, and data processing and representation in 2D and 3D systems were carried out using Excel software and Jandel Table Curve 3D v2.

Statistical analysis of comfort indicators characterizing waterproof fabrics depending on the treatment parameters of the installations (pressure, temperature, velocity) was conducted through correlation/graphing methods, and mathematical model estimation leads to practical conclusions regarding the dependency between variables.

RESULTS AND DISCUSSION

Within this study, both theoretically and experimentally, the effect of low-pressure hot air jet temperature variation on the vaporization coefficient, air permeability index, and thermal conductivity coefficient was analysed. Applying the correlation/graphing method in both 2D and 3D systems, the main comfort indicators were analysed: vapour permeability coefficient/vaporization coefficient, μ (g/m^{2}h), air permeability index, I (kg/m^{2}h), and thermal conductivity coefficient, λ (kcal/mh°C), depending on the treatment temperature of the installation in the material assembly zone. Correlating these indicators is notably evident in the 3D processing, which strengthens the conclusions obtained and presented following the 2D processing.

The research on comfort indicators was conducted under the optimization of treatment parameters, ensuring that in these conditions, the durability and presentation value functions in the treatment zone remain unchanged compared to those of the base materials.

The experimental investigations were based on the values obtained for the corresponding standard sample material, coded as PE, for which the following values were established:

- vapour permeability coefficient/vaporization coefficient, μ = 7.80 g/m^{2}h;
- air permeability index, I = 37.62 kg/m^{2}h;
- thermal conductivity coefficient, λ = 0.058 kcal/mh°C.

Considering the wide range of temperature variation, between the limits of 255°C – 422°C, 10 experimental samples were conducted in the assembly zone, coded from P1 to P10, along with a sample for the base material, considered as the standard sample, coded as PE.

From table 1, it can be observed that the experimental research regarding the determination of the vapour permeability coefficient was conducted under conditions of varying temperature, T (°C), while maintaining constant pressure, p = 400 kPa, and the speed of the semifinished product, v = 80 cm/min.

Table 1

VALUES OF THE VAPOR PERMEABILITY COEFFICIENT/VAPORIZATION COEFFICIENT

Sample code	Temperature T (°C)	Vapour permeability P_v (g)	Vapour permeability coefficient μ (g/m²h)
P1	255	0.298	6.34
P2	306	0.275	5.85
P3	311	0.271	5.77
P4	331	0.261	5.55
P5	342	0.259	5.51
P6	349	0.251	5.34
P7	403	0.23	4.89
P8	405	0.234	4.98
P9	412	0.214	4.55
P10	422	0.209	4.45
PE	STANDARD SAMPLE		7.80

The data obtained regarding the vapour permeability coefficient as a function of treatment parameters of the installation, for the production of products serving as substitutes for waterproof materials using Gore-Tex films, intended for manufacturing outerwear garments such as protective equipment (jackets and overalls), are analysed in the 2D system and graphically represented in figure 4.

From the bar chart illustrated in figure 4, it can be observed that as the temperature increases, the vapour permeability coefficient decreases.

Additionally, the value of the vapour permeability coefficient for the waterproof material is lower than the value obtained for the standard sample. This is justified by the presence of Gore-Tex films, which are breathable waterproof membranes.

The relationship between the vapour permeability coefficient and temperature is depicted in figure 5 using the correlation/graphing method in the 2-D system, complemented with the corresponding mathematical model and correlation coefficient.

The analysis of this vapour permeability coefficient characterizing waterproof fabrics was conducted using the correlation/graphing method, with the model parameter estimation performed using Excel software.

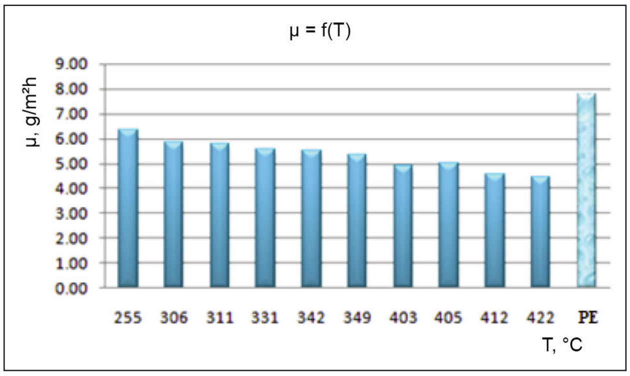

Fig. 4. Graphical representation of the vapour permeability coefficient as a function of temperature

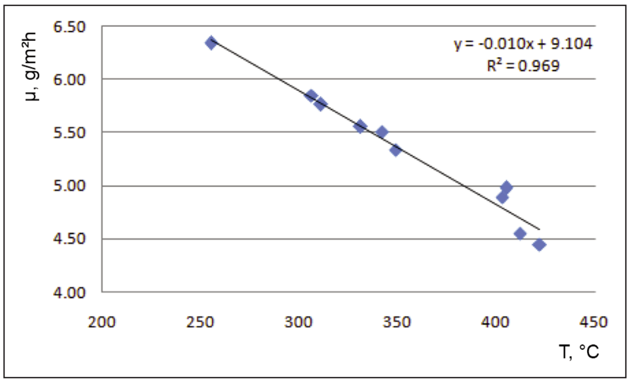

Fig. 5. Graphical representation indicating the relationship between the vapour permeability coefficient and temperature

Analysing the mathematical model allows for practical conclusions regarding the dependency between the vapour permeability coefficient and temperature:

- The correlation graph between the vapour permeability coefficient/vaporization coefficient, μ (g/m²h), and temperature, *T* (°C) shown in figure 5, highlights the nature and intensity of this relationship.
- For the correlation μ = *f*(*T*), the coefficient of determination has the value $R^2 = 0.969$, indicating that 96.9% of the vapour permeability coefficient is influenced by temperature.
- After distributing the points corresponding to the 10 pairs of individual values of the vapour permeability coefficient and temperature, it is observed that there is a very strong, indirect relationship between the two variables, with $R = 0.984$ and $R^2 = 0.969$ ($0.75 \leq 0.984 \leq 1$). The regression line equation for the studied correlation is:

$$Y = -0.010X + 9.104 \Leftrightarrow \mu = -0.010T + 9.104 \quad (1)$$

- The probability that the model is correct is relatively high, around 98%. This conclusion can be expressed based on the values determined in Excel through the testing of R Square (0.969) and Adjusted R Square (0.965). The validity of the model is confirmed by the regression test values $F_{calc} = 250.13$, which is greater than the tabulated $F_{tab} = 3.18$, considered as the basis for comparison in the analysis of econometric model validity. The degree of risk is nearly zero (reflected by the Prob F-statistic test value).
- The high value of the constant term reflects the significant influence of unspecified factors in the model on the evolution of the resultant variable μ (g/m²h). This leads us to the conclusion that the model used (although correct) can be further developed to ensure better results for characterizing waterproof fabrics.
- To verify the significance of the linear correlation coefficient, the t-test (Student's t-test) is applied by calculating the variable $t_{calc} = -19.872$ and comparing it with the tabulated critical value. With a

probability of 95% and for 9 degrees of freedom, t_{tab} = 1.183. Since $|t_{calc} = 19.872| > |t_{tab} = 1.183|$, it can be appreciated that the hypothesis of correlation significance is verified, and there is a significant relationship between the investigated variables. Therefore, the correlation coefficient $R_{Y/X}$ is statistically significant, and the analysis model is correctly specified.

From table 2, it follows that experimental research regarding the determination of the air permeability index I (kg/m^{2}h) was conducted under conditions where the temperature, T (°C), varied while maintaining constant pressure at p = 400 kPa and the displacement speed of the semifinished product at v = 80 cm/min.

As observed from table 2 and figure 6, the values of the air permeability index vary depending on the technological parameters of the process, specifically, the values increase as the temperature of the air jet at the outlet of the heating system increases, while keeping the pressure (p = 400 kPa) and welding speed (v = 80 cm/min) constant, equivalent to the tangential speed of the conveyor rollers.

From the analysis of the mathematical model obtained in the 2D system, as shown in figure 7, regarding the relationship between the air permeability index and temperature, the following conclusions can be drawn:

Table 2

VALUES OF THE AIR PERMEABILITY INDEX			
Sample code	**Temperature T (°C)**	**Air permeability P_a (m^3/min·m^2)**	**Air permeability index I (kg/m^{2}h)**
P1	255	0.3167	22.8
P2	306	0.3333	24
P3	311	0.3667	26.4
P4	331	0.3833	27.6
P5	342	0.4000	28.8
P6	349	0.4333	31.2
P7	403	0.4500	32.4
P8	405	0.4833	34.8
P9	412	0.5000	36
P10	422	0.5250	37.8
PE	STANDARD SAMPLE		39

- For the correlation $I = f(T)$, the coefficient of determination has a value of R^2 = 0.966, meaning that 96.6% of the air permeability index is influenced by temperature.
- There is a very strong direct relationship between the two variables with R = 0.933 and R^2 = 0.966 (0.75 ≤ 0.933 ≤ 1). The regression line equation for the studied correlation is:

$$Y = 0.089X - 1.299 \Leftrightarrow I = 0.089T - 1.299 \quad (2)$$

- The probability that the model is correct is relatively high, approximately 93%. This conclusion is based on the values determined in Excel through the testing of R Square (0.933) and Adjusted R Square (0.925). The validity of the model is confirmed by the values of the regression tests: F_{calc} = 111.72, a value greater than the tabulated F_{tab} = 3.18, considered as the basis for comparison in the analysis of the validity of econometric models, with a near-zero degree of risk (reflected by the value of the Prob F-statistic test).
- The high value of the constant term indicates that the influence of unspecified factors in the model on the evolution of the resultant variable I (kg/m^{2}h) is significant. Therefore, it can be concluded that although the model used is correct, it can be further developed to ensure better results for characterizing waterproof fabrics.
- To verify the significance of the linear correlation coefficient, the t-test (Student's t-test) is applied by calculating the variable t_{calc} = –18.377 and comparing it with the tabulated critical value. With a probability of 95% and for 9 degrees of freedom, t_{tab} = 1.183. Since $|t_{calc} = 18.377| > |t_{tab} = 1.183|$, it can be appreciated that the hypothesis of correlation significance is verified. Therefore, the correlation coefficient $R_{Y/X}$ is statistically significant, and the analysis model is correctly specified.

The experimental values for determining the thermal conductivity coefficient, λ (kcal/mh°C), presented in table 3, were obtained under the same conditions as the vapour permeability coefficient and the air permeability index, by varying the temperature and

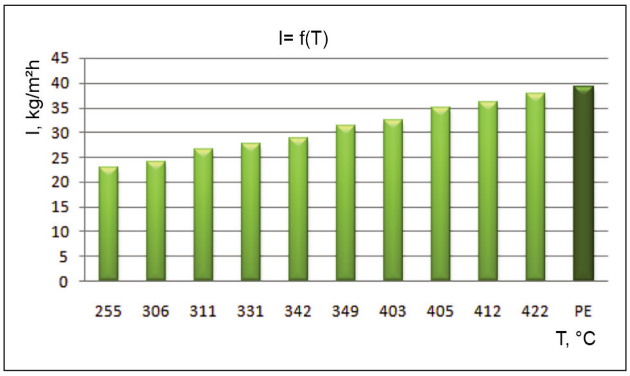

Fig. 6. Graphical representation of the air permeability index as a function of temperature

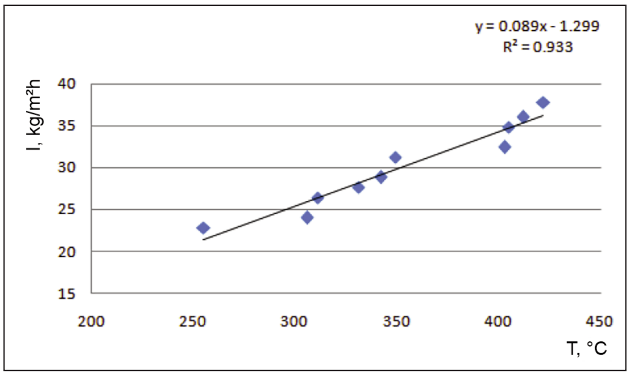

Fig. 7. Graphical representation indicating the relationship between the air permeability index and temperature

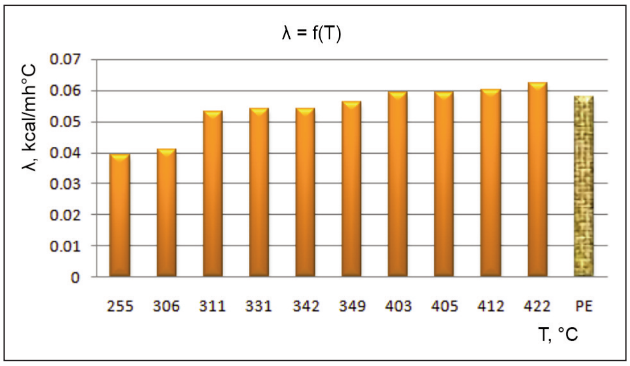

Fig. 8. The graphical representation of thermal conductivity as a function of temperature

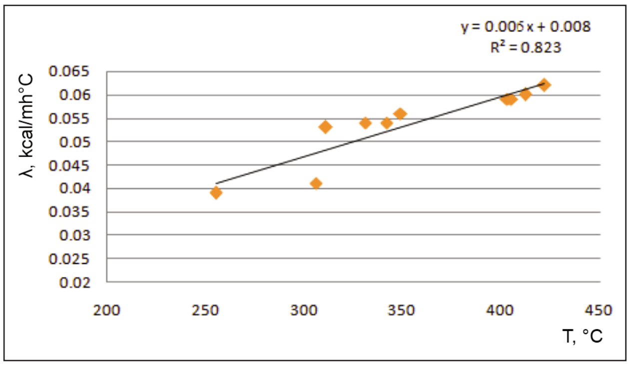

Fig. 9. Relationship between thermal conductivity and temperature

Table 3

VALUES OF THE THERMAL CONDUCTIVITY COEFFICIENT		
Sample code	**Temperature T (°C)**	**Thermal conductivity coefficient λ (kcal/mh°C)**
P1	255	0,039
P2	306	0.040
P3	311	0.053
P4	331	0.054
P5	342	0.054
P6	349	0.056
P7	403	0.059
P8	405	0.059
P9	412	0.06
P10	422	0.062
PE	STANDARD SAMPLE	0.058

keeping the pressure (p = 400 kPa) and the speed of the semifinished product (v = 80 cm/min) constant.

From table 3 and figure 8, it can be observed that sample P1 has the lowest values of the thermal conductivity coefficient, μ = 0.039 kcal/mh°C, which is a suitable variant within the specified limits. This is also reflected in the value of the air permeability index, I = 22.8 kg/m^{2}h. These values indicate that the spaces between fibres and yarns are reduced, confirming the good thermal insulation capacity of this type of material.

Analysing the mathematical model obtained through the correlation method in the graphical representation from figure 8, the following conclusions can be drawn:

- For the correlation $\lambda = f(T)$, the coefficient of determination is $R^2 = 0.908$, indicating that 90.8% of the thermal conductivity coefficient's value is influenced by temperature.
- The correlation graph between the thermal conductivity coefficient λ (kcal/mh°C), and temperature T (°C), highlights the nature and intensity of this relationship.
- After examining the distribution of points corresponding to the ten pairs of individual values of thermal conductivity coefficient and temperature, it is observed that there is a very strong indirect relationship between the two variables, with a correlation coefficient of $R = 0.823$ and a coefficient of determination of $R^2 = 0.908$, $(0.75 \leq 0.823 \leq 1)$. The regression line equation for the studied correlation is as follows:

$$Y = 0.005X + 0.008 \Leftrightarrow \lambda = 0.005T + 0.008 \quad (3)$$

- The probability of the model being correct is relatively high, approximately 82%. This conclusion is based on the values determined in Excel through the testing of R Square (0.823) and Adjusted R Square (0.802). The validity of the model is confirmed by the regres-sion test values: $F_{calc} = 37.409$, which is greater than the tabulated $F_{tab} = 3.18$, considered as the basis for comparison in the analysis of the validity of econometric models. Additionally, the risk level is close to zero, as reflected by the value of the Prob F-statistic test.
- To verify the significance of the linear correlation coefficient, the t-test (Student's t-test) is applied. By calculating the variable $t_{calc} = -20.1741$ and comparing it with the critical value, which is tabulated. With a 95% probability and for 9 degrees of freedom, $t_{tab} = 1.183$. Since $|t_{calc} = 20.1741| > |t_{tab} = 1.183|$, it can be appreciated that the hypothesis of correlation significance is verified. Therefore, there is a significant statistical relationship between the investigated variables, and the correlation coefficient $R_{Y/X}$ is statistically significant, indicating that the analysis model is correctly specified.

Analysis in the 3D system led to the derivation of complex mathematical models depicted in figure 10, realized in the tri-orthogonal system, from which the correlation coefficient is also derived. It is emphasized that from the set of mathematical models displayed, the model that best and most clearly expresses the interdependence between the three comfort indicators: vapour permeability coefficient μ (g/m^{2}h), air permeability index I (kg/m^{2}h), and thermal conductivity coefficient λ (kcal/mh°C), has been chosen. From the analysis of the mathematical model and the 3D graphical representation in figure 10, the following aspects are evident:

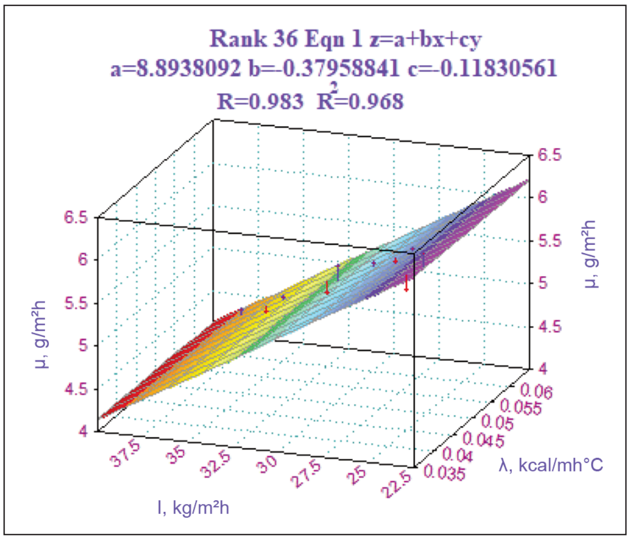

Fig. 10. Variation of the thermal conductivity coefficient as a function of the air permeability index and the vapour permeability coefficient

- The statistical relationship between the thermal conductivity coefficient, the air permeability index, and the vapour permeability coefficient is highlighted by the multiple correlation coefficient $R = 0.983$ and $R^2 = 0.968$, $(0.75 \leq 0.983 \leq 1)$, with significance certified by the F-test: $F_{calc} = 95.978$; $F_{tab} = 3.18$; $F_{calc} > F_{tab}$.
- The regression equation for the correlation studied is:

$$Z = 8.8938 + 0.3796X + 0.1183Y \Leftrightarrow$$

$$\lambda = 8.8938 + 0.3796I + 0.1183\mu \quad (4)$$

- The probability that the model is correct is relatively high, approximately 98%. This conclusion is based on the values determined in the Jandel Table Curve 3D v2 program, with a correlation coefficient of $R = 0.983$ and Adjusted R Square (0.9472).
- To verify the significance of the correlation coefficient, the t-test (Student's t-test) is applied by calculating the variable $t_{calc} = 15.28$ and comparing it with the critical value, tabulated as $t_{tab} = 1.83$ for a 95% probability and 9 degrees of freedom. Since $|t_{calc} = 15.28| > |t_{tab} = 1.83|$, it can be concluded that the hypothesis of the significance of the correlation is verified. Therefore, there is a statistically significant relationship between the variables under study, and the correlation coefficient is statistically significant, confirming that the analysis model is correctly specified.
- There is a slight decrease in the coefficient of thermal conductivity, very close to the increase in the permeability index to air, but a more pronounced effect on its decrease is observed with the increase in the permeability coefficient to vapours. This is consistent with the specific physical processes that occur in the body-clothing-environment relationship. When heated by sweating, the human body needs to dissipate more heat, and at the same time, there must be the possibility of ventilation.

Table 4

CENTRALIZATION OF MATHEMATICAL MODELS		
Processing systems	**Mathematical model**	**Correlation coefficient**
2D	$\mu = -0.010T + 9.104$	$R^2 = 969$
	$I = 0.089T - 1.299$	$R^2 = 0.966$
	$\lambda = 0.005T + 0.008$	$R^2 = 0.908$
3D	$\lambda = 8.8938 + 0.3796I + 0.1183\mu$	$R^2 = 0.968$

- Complex mathematical models and correlation coefficients $R > 0.95$ certify the accuracy of the experimental results and also support optimization elements. This indicates the correlation of specific treatment parameters of the analysed technology with parameters influencing comfort.

The databases of experimental data and graphical representations containing verifiable mathematical models can be considered optimization elements, considering the limits of correlation coefficient values $R > 0.90$ obtained both in the 2D system and in the 3D system. This is also evident from table 4, which centralizes the mathematical models obtained following the processing in both 2D and 3D systems.

CONCLUSIONS

This study highlights the results regarding the optimization of comfort indicators in connection with the specific parameters of unconventional assembly technology. This necessitated the presentation of general aspects concerning the welding mechanism, the relationship between comfort influence indicators, and specific treatment parameters.

Considering the wide range of temperature variation, between the limits of 255°C – 422°C, $p = 400$ kPa and a displacement speed $v = 80$ cm/min, the experimental values of comfort indicators approach those of the standard sample and can be considered optimal values in the assembly area.

Materials with GORE-TEX film used in jackets and overalls are joined by seams, allowing us to identify the sealing of the seams through visible tape strips around the seams and other details to reinforce potential water infiltration gaps. This will provide a reliable, complete, waterproof, and weather-resistant finish.

The experimental research can be associated with the technology used to produce the products presented in the study, which shows an extended demand both in the domestic and international markets. The analysis results can be subsequently used for modelling the physico-mechanical properties of fabrics and for selecting the most suitable fabrics to meet the requirements of a specific field of use.

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