EVALUATION OF 3D KNITTED FABRICS TO PROTECT AGAINST MECHANICAL RISK AND SUITABLE TO WEAR NEXT TO SKIN

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EXTENDED ABSTRACT

Key Words: 3D WEFT KNITTED FABRIC, PROTECTION AGAINST MECHANICAL RISK, CUT RESISTANCE, PROTECTIVE TEXTILE, COMFORT.

1. INTRODUCTION

The major function of materials, used for protective gloves, jackets, arm guards against mechanical risk, is to reduce hazards. Although requirements for comfort during wearing, including flexibility and thermo-physiological properties such as air permeability should also be considered. The main advantage of 3D fabrics, knitted using weft knitting technology, is the possibility to use different raw materials – high-performance fibres and conventional fibres, in different layers, giving an opportunity to achieve an optimal ratio between protection and comfort properties [1-4].
The aim of this research was to identify how the index of resistance and comfort properties of the 3D weft knitted fabrics varies when changing their composition and structural parameters, such as the quantity of steel wire, stitch density and others.

2. MATERIALS AND METHODS

In this research 8 different 3D knitted fabrics were investigated. Fabrics were knitted on a circular weft knitting machine with two different gauges: 20E and 28E. Four different raw materials were used to manufacture 3D knitted fabrics. In the outer layer high-performance polyethylene (HPPE) multifilament yarns and 0.05 mm diameter steel wire twisted with HPPE for better resistance to mechanical risks were used. In the binding layer elastic polyamide yarns (PA) were used to connect outer and inner layers together. In the inner layer hydrophobic polyester spun yarns (PES Coolplus) suitable to contact with the skin were used.
Before testing all the materials were conditioned in the standard atmosphere conditions (temperature T = 20 ± 2 °C; relative humidity φ = 65 ± 2 %) for 24 hours according to EN ISO 139:2005 [5]. The stitch density of the knitted fabrics was calculated from courses per centimetre (CPC) and wales per centimetre (WPC) with the help of optical microscope according to standard LST EN 14971:2006 [6]. The thickness h was measured according to standard EN ISO 5084:2000 [7] and the mass per unit area W was determined following EN ISO 12127:1999 [8] standard. The physical characteristics of the 3D weft knitted fabrics are given in Table 1.
According to the standard EN 388:2003 [9] circular blade cut, puncture and abrasion resistance tests have been conducted to determine the resistance to mechanical risks.

Table 1. The characteristics of tested 3D weft knitted fabrics

Materials code	CPC	WPC	Stitch density, cm^{-2}	Thickness h, mm	Mass per unit area W, g/m^2
20E-1-0	11	12	132	1.2 ± 0.03	381 ± 4.4
20E-1-2V	11	11	121	1.3 ± 0.06	370 ± 1.7
20E-1-2H	11	11	121	1.3 ± 0.05	374 ± 1.9
20E-1-1	12	10	120	1.3 ± 0.04	418 ± 1.5
28E-1-0	14	14	196	1.5 ± 0.03	439 ± 2.8
28E-1-2V	15	13	195	1.5 ± 0.03	528 ± 2.3
28E-1-2H	15	13	195	1.5 ± 0.01	524 ± 4.5
28E-1-1	18	12	216	1.7 ± 0.08	711 ± 6.2

CPC – courses per centimetre; WPC – wales per centimetre.

The circular blade cut resistance tester “SATRA STM 611” was used to measure cut resistance of 3D weft knitted fabric samples. Zwick/Roell (Z050) tester was used to measure puncture resistance of the samples. The resistance to abrasion was evaluated by a Martindale abrasion tester “SATRA STM 633”.

Comfort properties such as air permeability, bending rigidity and thermal efficiency have been investigated as well. Air permeability values were determined using instrument ATL-2 according to standard LST EN ISO 9237:1997 [10] under specified conditions where pressure of difference was 200 Pa and the circular test area was 10 cm^2. The air permeability AP was determined according to the equation (1):

$$AP = \frac{q}{A}, \text{dm}^3/(\text{m}^2\text{s}); \quad (1)$$

where q is air flow that passes the sample (dm^3/h); A – an operative area of the sample (m^2).

In order to determine the thermal effect of the 3D weft knitted fabrics an infrared lamp (100 W, 240V) as a heat source and a thermal camera Infra CamTM were used. The distance between the sample and a heat source - infrared lamp, was 25 centimetres. The specimen was placed on a flat surface - polystyrene foam. When the infrared lamp was switched on, the temperature of heating of the sample was registered every 15 seconds for 4 minutes by the thermal camera. After 4 minutes the infrared lamp was turned off and the cooling temperature of the sample was registered every 15 seconds for 4 minutes as well. The results of the measurements were averages from the values of five samples.

The bending rigidity B was determined using FAST method and calculated by the following equation (2) [11]:

$$B = W \times \left(\frac{l}{2}\right)^3 \times 9{,}81 \times 10^{-6}, \mu\text{Nm}; \quad (2)$$

where W – mass per unit area (g/m^2); l – bending length (mm).

3. RESULTS AND CONCLUSIONS

The research reflected that the blade cut resistance index and abrasion resistance have a strong positive relationship to the amount of steel wire in the structure of the 3D weft knitted fabric as well as mass per unit area. It was defined that fabrics knitted on a circular weft knitting machine of gauge 28E ensured greater blade cut, puncture and abrasion resistance results, than the fabrics knitted by gauge 20E due to a higher stitch density, mass per unit area *W*, thickness *h*. Contrarily, 3D fabrics, knitted by gauge 20E, ensured better comfort properties – air permeability, they were more flexible and accumulated less heat than fabrics knitted by 28E gauge, due to a lower stitch density, mass per unit area and thickness.

4. REFERENCES

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