RESEARCH ON INFLUENCE OF TiSi(N) REFLECTIVE COATING THERMAL RESISTANCE ON ENERGY ABSORPTION OF FIREPROOF TEXTILE COUPLED WITH AUXETIC FABRIC

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1. Introduction – aim of research

Textile science is a very wide and still developed part of knowledge. In the presented study the special interest is directed to fireproof textiles improvement. Fireproof textiles are a kind of fabrics more resistant to fire or heat than others through chemical treatment or specially manufactured fibres.
Such fibres could be classified into three categories. The first one are inherently heat and flame retardant fibres (e.g. aramid [1], modacrylic [2], polybenzimidazole (PBI) [3], Panox (oxidised acrylic) [4] or semicarbon, phenolic, asbestos, ceramic [5]). The second cathegory are chemically modified fibres and fabrics, in which one can find flame retardant cotton, wool and viscose [6] and synthetic fibres [7], produced by incorporating special additives in the spinning dope before extrusion. The last cathegory of a fireproof textiles are currently developed [8, 8] fibres coated with reflective nanolayer with the use of sputtering method.
In the paper the thermal resistance improvement is based on the TiSi(N) nanocoating application with the use of sputtering technology.
Additionally it must be noticed that fireproof textiles are not designed to improve the protection against for example gas impact, the possible situation during fire of houses or flats. For this improvement the auxetic textile coupled with fireproof one was proposed. Auxetics are new materials which fibre diameter widens on stretching it whereas normal textiles flat (Fig. 1).

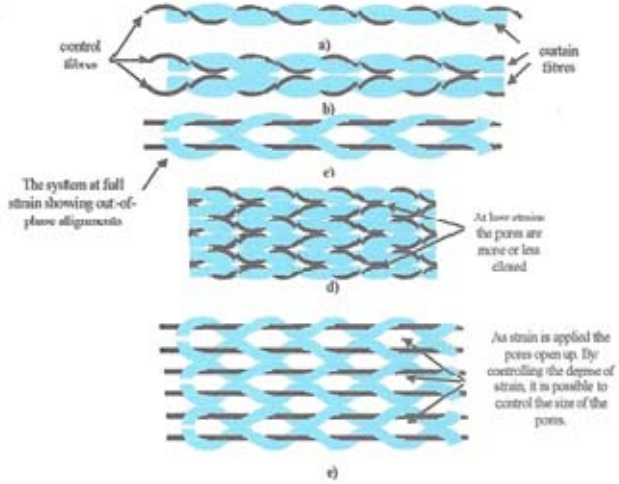

Fig. 1. Basic concept of auxetic textile: a) base textile unit – thin yarn winded around thick core, b) two base units aligned in opposite to each other, c) fully tensiled pair of unit yarns, d) partially tensiled textile, e) fully tensiled textile [10]

There are two main disadvantages of auxetics implementation in such constructions as firemen protective clothes. Firstly, they must be stretched during loading to gain the negative Poisson ratio effect. Secondly, the auxetic effect decreases in higher temperatures [11]. Those properties can be a problem when the textile is used for firemen suits. The best application can be a kind of a protective panel.
So the material construction of fireproof textile, additionally coated with reflective nanocoating, and auxetic

one can improve both mechanical and thermal protection. The fireproof textile will protect the user against the high temperature and will protect the auxetic textile allowing to use its energy absorption abilities in the most effective way. This phenomenon is studied in the paper.

2. Researched materials and metchodology

For the purpose of proposed research PROTON fireproof textile was selected. PROTON is made of paraaramid 58%, PBI 40%, antistatic 2%. The applied auxetic fabric is composed of elastomer core and Kevlar braid.
Two kinds of tests were carried out:

- comparative study on PROTON thermal resistance with and without TiSi(N) coating,
- comparative study on PROTON and PROTON – auxetic structure gas impact resistance.

Special testing stands were built to achieve those aims. It must be mentioned that there is no influence of coating on PROTON gas impact resistance, what was shown in [12].

3. Results and conclusions

As it was shown in [11] the temperature increase from 20 to 180°C causes the decrease in auxetic effect of even 13.2%.
The results of thermal resistance of coated and not coated PROTON shown that the application of such structure can decrease the temperature acting behind the textile from 180 to 100°C (45%).
The next tests shown that the application of the auxetic textile can increase the PROTON resistance to gas impact of 18.2 %.
Finally on the base of achieved results it can be concluded that using both improvement: TiSi(N) nanocoating and auxetic fabric can improve energy absorption and thermal resistance of fireproof textile.

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References

[1] Teijin Ltd.. Super FR cloth. *Textile Horizons*, 9:31, 1989.
[2] A. R. Harrocks, S. C. Anand. *Handbook of Technical Textiles*. Woodhead Publishing Limited, Cambridge, 2000.
[3] D. T. Ward. High Tech. Fibres featured at Frankfurt show. *International Fibre Journal*, 6:89, 1991.
[4] N. Saville, M. Squires. *Multiplex panotex textiles*. International Conference Industrial and Technical Textiles, University of Huddersfield, UK, 6-7 July 1993.
[5] P. Lennox – Kerr. Friction spinning creates hybrid yarns for improved thermal protection. *Technical Textiles International*, 6:18, 1977.
[6] S. Heidari, A. Paren, P. Nousianinen. The mechanism of fire resistance in viscose/silicic acid hybrid fibres. *Journal of Society of Dyers and Colourists*, 109:201, 1993.
[7] Z. Ma, W. Zhao, Y. Liu, J. Shi. Synthesis and properties of intumescent phosphorus-containing flameretardant polyesters. *Journal of Applied Polymer Science*, 63:1511, 1997.
[8] E. Małek, D. Miedzińska, M. Stankiewicz. Heat Resistance Research and Surface Analysis of Fireproof Textiles with Titanum Silicide Coating. *Procedia Structural Integrity*, 5:508, 2017.
[9] K. Marszałek, R. Mania. *The Nanocomposite TiN-Si3N4 coatings on textiles*. 9-th Symposium on Vacuum Based Science and Technology, Kołobrzeg, Poland, 16-18 November 2015,.
[10] J. R. Wright, K. E. Evans and M. K. Burns. *Auxetic Blast Protection Textiles – Crime Feasibility Study, Final Report– EP/D036690/1*. University of Exeter, 2007.
[11] M. Klasztorny, P. Szurgott, T. Niezgoda, D. Miedzińska, A. Kiczko. Preliminary Comparative Static Identification Research on Selected Commercial Auxetic Fabrics. *Composites Theory and Practice*, 17:59, 2017.
[12] D. Miedzińska, R. Gieleta, E. Małek, D. Zasada, M. Stankiewicz, K. Marszałek. Experimental research on influence of gas impact on thermal and mechanical properties of auxetic material covered with titanium silicide coating. *Bulletin of the Polish Academy of Sciences - Technical Sciences*, BPASTS-00464-2017-01, in press, 2018.