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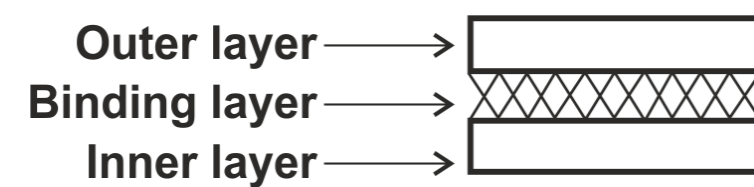
INTRODUCTION

Every year, many workplace injuries occur in the world that can be prevented by using appropriate protective clothing. Puncture and tear resistance are among the mechanical properties required in protective clothing in order to avoid serious injuries in the workplace. Textile materials are complex therefore investigations of puncture also tear resistance are highly demanded to determine the effect of different parameters of knitted fabrics on mechanical risk. Also, comfort properties such as air permeability is an important characteristic that should be evaluated as well because the wearer can perform well only if feels comfortable when wearing personal protective equipment.

This study aimed to determine the influence of 3D weft-knitted fabric fibre composition on the puncture, tear risk and to evaluate the air permeability of these protective knitted fabrics.

MATERIALS

3D weft-knitted fabrics, consisting of outer (protective layer), binding, and inner layer (suitable for direct contact with skin), were designed and produced on a E20 circular weft-knitting machine.



Schematic representation of 3D weft-knitted fabric structure

Four types of yarns were used to produce 3D weft-knitted fabrics for this study: 1) high molecular weight polyethylene filament yarns (HMWPE, 22.2x2 tex) (outer layer). 2) Inorganic filament yarns 22.2 tex (outer layer). 3. Polyamide (PA, 3.2x2 tex) (binding layer). 4. Polyester (PES, 11.1x4 tex) (inner layer).

The percentage composition of the raw materials in the 3D weft-knitted fabrics

Type of yarns \ Sample code	1S	2S	3S_V	4S_H	5S	6S
HMWPE yarns, % (outer layer)	49	43	37	37	31	24
Inorganic yarns, % (outer layer)	0	5	12	12	17	23
PA, % (binding layer)	6	6	6	6	6	6
PES, % (inner layer)	45	46	45	45	46	47

METHODS

The puncture, tear resistance tests were performed to determine the resistance of 3D weft-knitted fabrics to mechanical risks in accordance with EN 388:2016. A SATRA STM 566 Tensile testing machine was used for the puncture resistance testing to determine the force required to cause a standard puncture needle to break through a knitted fabric. The test was performed at a test speed of 100 mm/min on four different specimens for each knitted fabric. A SATRA STM 566 Tensile tester was used to determine the maximum force necessary to propagate a tear in a rectangular specimen of the 3D knitted fabric slit halfway along its length. Trousers-type samples (100x50 mm) with an incision in the longitudinal direction of the sample were investigated, i.e., four specimens were cut both in the course direction and the wale direction. The test was performed at a test speed of 100 mm/min.



Setup for puncture resistance test



Setup for tear resistance test

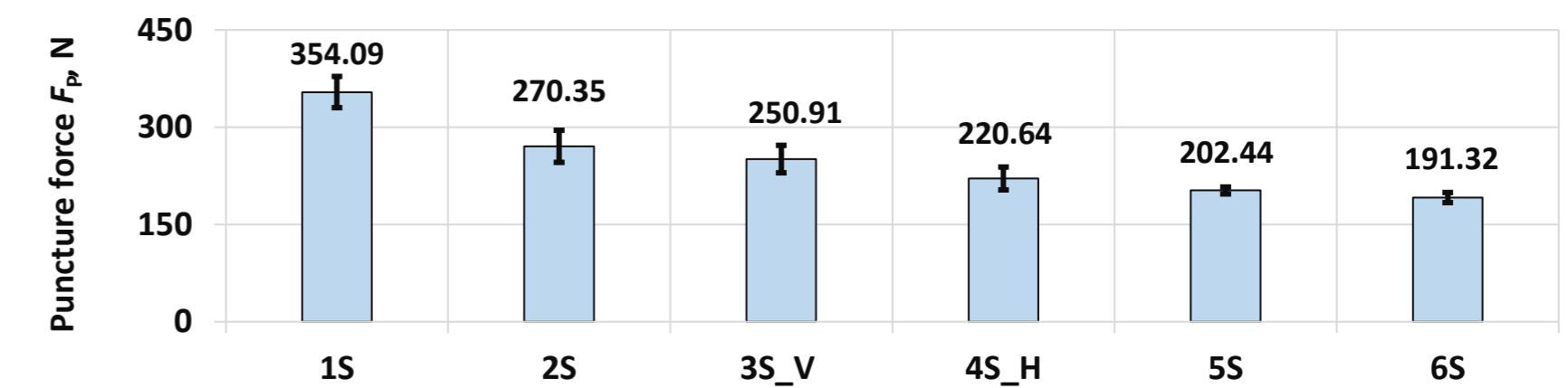
All levels of performance achieved during the puncture and tear resistance tests were assessed in accordance with the EN 388:2016, where Level 1 represents the lowest and Level 4 the highest protection level.

Levels of performance according to EN 388:2016

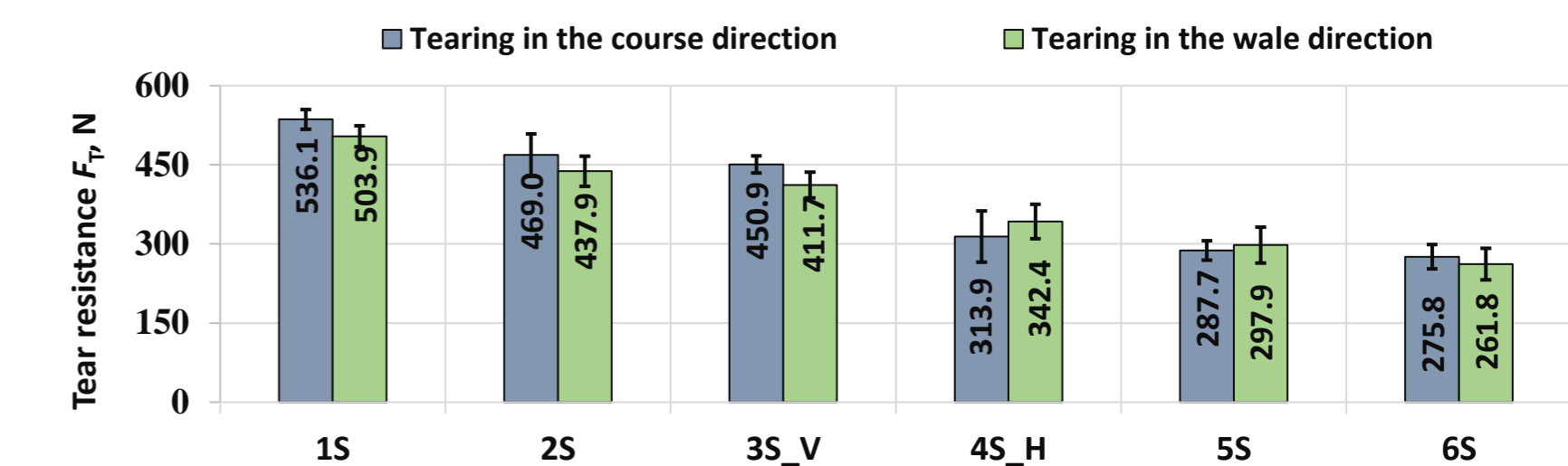
Test	Level 1	Level 2	Level 3	Level 4
Puncture resistance (N)	20-59	60-99	100-149	≥150
Tear resistance (N)	10-24	25-49	50-74	≥75

The air permeability of 3D weft-knitted fabrics was investigated in accordance with EN ISO 9237:1995 using a pressure of 200 Pa. Ten tests were conducted for each 3D weft-knitted fabric.

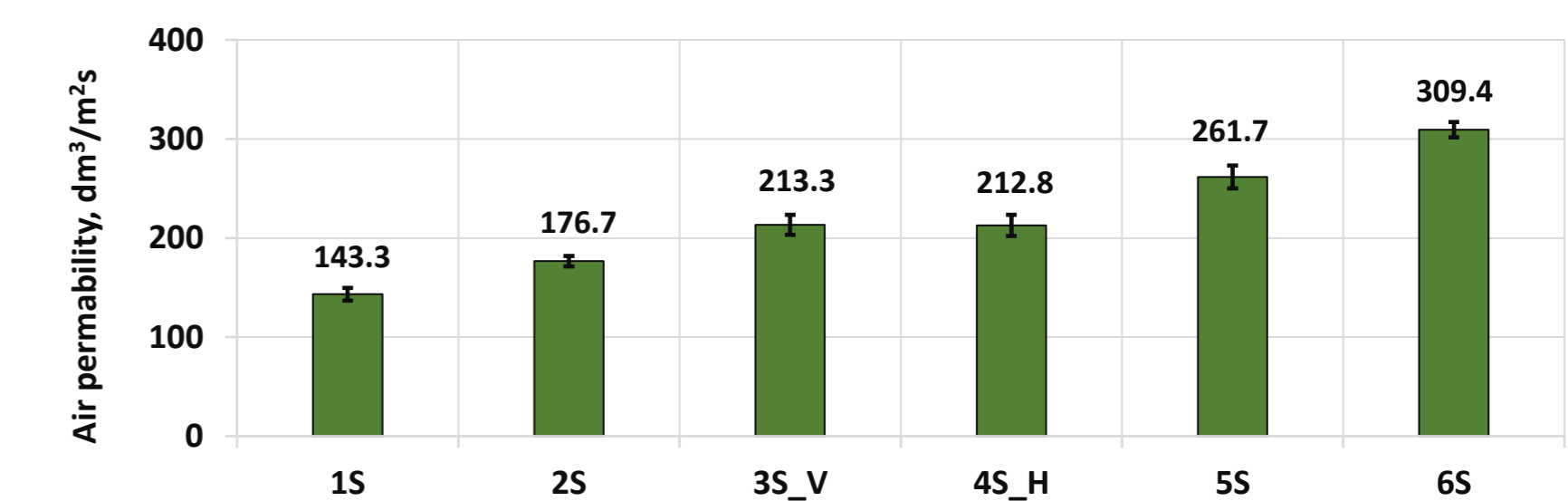
RESULTS



The results of puncture resistance test



The results of tear resistance test



The results of air permeability test

CONCLUSIONS

- ❑ 3D weft-knitted fabric (1S) with the highest percentage of high molecular weight polyethylene (HMWPE) in its structure is the most resistant to puncture and tear risks.
- ❑ All the investigated 3D weft-knitted fabrics comply with the highest puncture and tear resistance (level 4) in accordance with EN 388:2016.
- ❑ The air permeability of the investigated 3D weft-knitted fabrics enlarges by increasing inorganic fibre in the knits.