STAB RESISTANT KNITTED CLOTHING

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Abstract

Stab and cut resistant textiles are mostly produced from aramide or ultra-high molecular weight polyethylene (UHMW-PE). These materials have stab resistant properties combined with a lower weight compared to chain mails.

In a recent ZIM project, knitted structures with stab resistant properties have been developed for a safety jacket, combining cut resistant yarns with a loop form, similar to chain mail. Compared to woven fabrics or nonwovens, knitted fabrics offer an enhanced drapability, which makes them better suited for being used in a jacket with high wearing comfort.

In the Niederrhein University of Applied Sciences, fabrics have been knitted by using different structures, yarns, and yarn combinations. They have been finished with diverse methods (coating, laminating, felting …) and evaluated in order to optimize the combinations of yarn, structure, and finishing with respect to their stab resistance properties.

The project partner Bache Innovative has developed several models of knitted safety jackets, starting from a light summer jacket with lower protective properties to models for people with particularly high risk potential, offering an increased stab resistance.

The results of stab resistance tests of different combinations of yarn, structure, and finishing as well as the different jacket models are presented.

Introduction

While stab resistant textiles are most often woven from aramide or ultra-high molecular weight polyethylene (UHMW-PE) [1,2], this approach is not ideal for a stab resistance jacket which should have a lower bending stiffness. Since knitted fabrics are more flexible and better drapable than woven ones, they are advantageous in garments like jackets, allowing for being worn without limitations of a person's ease of movement.

First tests with different materials have shown that yarns containing wool outside and aramide or UHMW-PE as a core have lower stab resistance properties than pure aramide or UHMW-PE yarns [3,4]. Additionally, aramide knitted fabrics suffer not only from UV instability, but also from structural distortions due to washing [4]. Thus the development depicted here concentrates on different structures knitted from pure UHMW-PE.

Experimental

The UHMW-PE used was Dyneema® Diamond Technology 3G12 440 dtex.

Knitted fabrics were prepared using a CMS 302 TC (Stoll) with gauge E8, an IBOM/B (Stoll) with gauge E10, and a CMS 330 TC 4 (Stoll) with gauge E12. The knitted structures

compared in our study are double face, interlock, French Piqué, Milanese, and different spacer fabrics. Additionally, an aramide nonwoven fabric, examined for different numbers of layers, has been used as a reference.

The stab resistance of the knitted fabrics was tested according to the VPAM test instruction “Stich- und Schlagschutz” [5]. For this, a stab resistance test stand was built (Fig. 1, left panel). In this test, a blade of defined shape and sharpness (Fig. 1, right panel) falls through the test fabric, driven by a weight of mass 2.5 kg and led by rails to avoid tilting of the knife. The test stand was planned for an adjustable falling height, therefore enabling even comparative measurements of fine fabrics with lower stabbing energy.

The tests are evaluated by measuring the penetration depth of the blade in the plasticine below the tested knitted fabric (Fig. 1, right panel). Additionally, the stitch width can be used to verify each depth measurement due to the unique correlation of blade width and length in the chamfered part.

Measurements have been performed min. 3 times per fabric; further tests were added if the first three measurements showed inconsistent results.

Fig. 1. Stab resistance test stand with rails leading the falling weight with the blade attached, electromagnet holding the falling weight and plasticine box (left panel), blade according to VPAM test instruction with typical cut in the plasticine.

Results

Fig. 2 shows penetration depth measurements, performed on UHMW-PE knitted fabrics, as a function of the fabric thickness and of the mass per unit area, respectively. Both graphs contain also the measurements on an aramide nonwoven, used as a benchmark.

Obviously, most UHMW-PE fabrics show better stab resistance properties than the aramide benchmark, i.e. lower penetration depth for lower fabric thickness or mass per unit area, respectively. The decision which fabrics are suited best for a stab resistant jacket depends on the question whether the fabric thickness or the mass per unit area are assumed to be

more important values for customers. Due to own tests, spacer fabrics and French Piqué, which are superior in both graphs, are both well suited; spacer fabrics, however, show a more constant performance, which can be recognized by the smaller error bar, and have thus been chosen as inlay material for the stab resistant jacket.

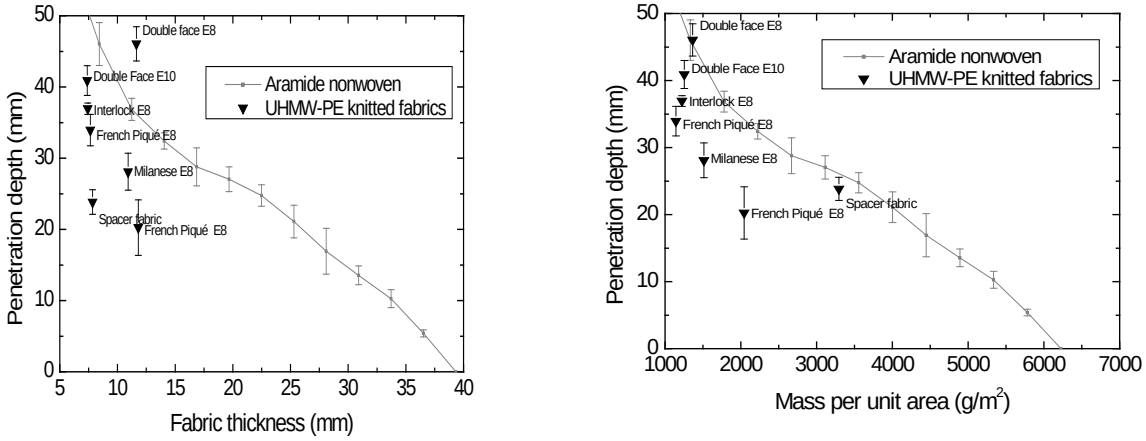

Fig. 2. Comparison of the penetration depths for different knitted structures from UHMW-PE as a function of the fabric thickness (left panel) and of the mass per unit area (right panel). From [4].

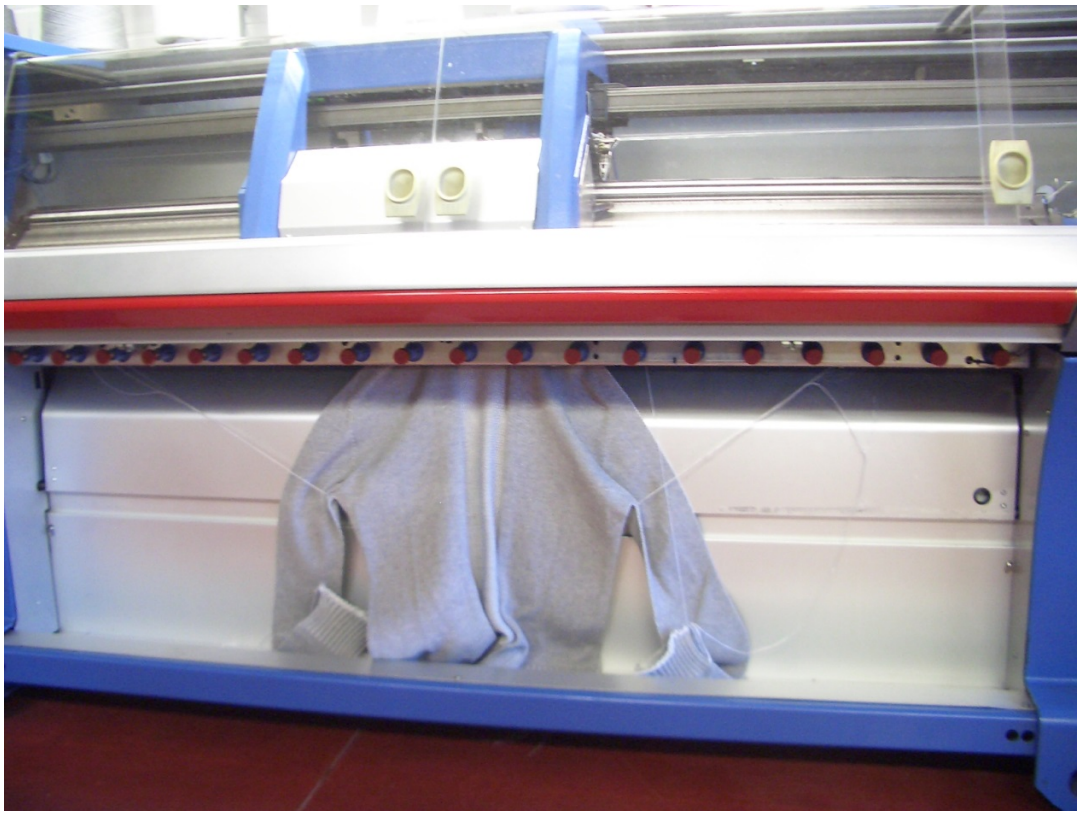

Fig. 3. Knit and wear® jacket, knitted from wool, plated inside with UHMW-PE.

The jacket itself was knitted on a CMS 730TC-S, gauge E5.2, from wool outside, plated with UHMW-PE inside, in knit and wear® technology (Fig. 3). While this jacket already offers a certain degree of stab resistance, the properties required according to the VPAM test

instruction are far from being reached. Therefore, inlays of two or four layers thickness have been added in the most endangered areas, i.e. front and back, to enhance the stab resistant properties. These additional layers have been knitted in form of spacer fabrics.

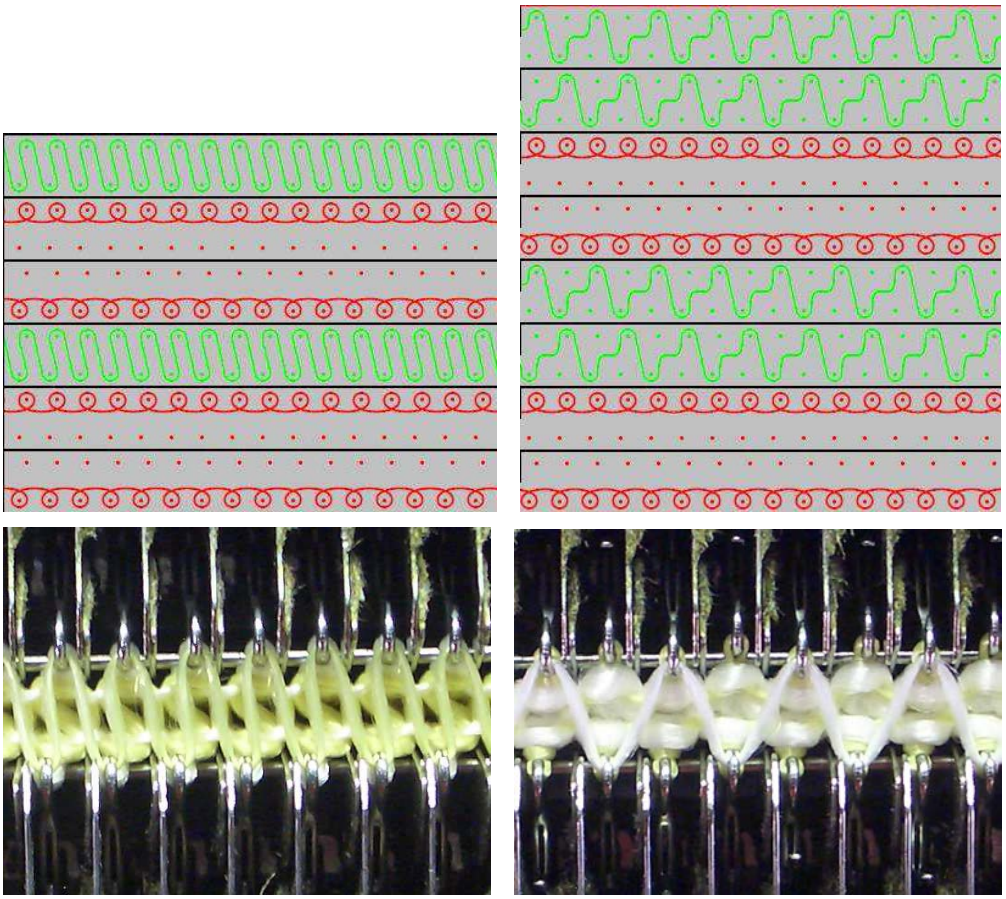

Fig. 4. Different spacer fabrics as needle notations (upper panels) and on the knitting machine (combinations of aramide and UHMW-PE).

Fig. 5. Complete jacket with four layers of additional stab resistant inlay.

Since there are several different spacer fabrics possible, some of them have been tested with respect to their stab resistance properties. Both variants depicted in Fig. 4 as needle notation and as photograph during the knitting process have shown nearly equally good stab resistance results, with the version depicted on the left being slightly better. Thus, this special spacer fabric has been chosen for the additional protection layers.

The complete jacket with four additional protection layers of an UHMW-PE spacer fabric included is depicted in Fig. 5. Even the four-layer variant is not significantly heavier or stiffer as a normal knitted jacket. The special thermo-conductive properties of UHMW-PE avoid stronger sweating than in a usual thin jacket. From outside, the stab resistance properties of the jacket are not visible – which is an important factor for people in “normal” jobs such as bus drivers or teachers, who are aware of the daily danger of being attacked but would not want to show anybody that they are wearing special protective clothing.

Summary

In a recent project, a stab resistant jacket has been developed which can be worn every day, due to its good comfort properties, thus allowing for a steady protection especially for people living in dangerous areas or having possibly dangerous jobs.

The jacket and the additional protective inlay have been tested according to the test instruction VPAM. Due to these tests, a spacer fabric from UHMW-PE has been identified as ideal knitted structure for the protective inlay.

Future experiments will concentrate on further enhancing the stab resistance properties and building up a collection of jackets with different protection properties.

Literature

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