INTEREST OF A COMPOUND YARN TO IMPROVE FABRIC PERFORMANCE

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Abstract

The market for protective clothing is growing in many fields, including flame resistance clothing, cut-resistance gloves and so on. High-performance fibres such as aramides are known to be flameproof and resistant to mechanical impacts, but they are sensitive to UV.The purpose of this study was to produce compound yarns with the advantageous properties of aramides and insensitive against UV radiation. We obtained such yarns by means of a friction process (FEHRER), a non-conventional spinning process. The yarn obtained, denoted as DREF yarn, developed by us is a combination of wool and poly-p-phenylenediamine-terephtalamide fibres (Kevlar®29). The compound yarn is composed of a core in Kevlar® yarn, coated by wool fibres. The DREF yarns were then knitted; the articles obtained have interesting properties such as flame retardancy, good-handle, cutting resistance, and are also UV-resistant.

1. INTRODUCTION

Textiles in many forms are used in interiors of public transportation (buses, aircrafts, cars, train and so on). These textile structures have to respect transportation legislation which is very strict regarding personal safety. However, the flame-retardant treatments suitable for these mainly wool-containing fabrics are generally not permanent after dry cleaning and laundry treatments 1. At the same time, the textiles used for these applications require other specific properties such as dyeability, good handle etc.This is why wool is particularly used as seat fabric in the interiors of buses and cars for its comfort and coloration properties , coupled with its low level of inherent flame resistance. However, the market increasingly requires highly flame- and heat-resistant textiles (such as seat coverings in aircraft) to have a combination of other acceptable properties including good handle.
The knitted articles obtained with compound yarns are studied with regard to different properties such as resistance to fire, cutting, dyeing and abrasion. The effect of UV on their behaviour has been analysed.

2. EXPERIMENTAL

2.1 Materials

Poly-p-phenylenediamine-terephtalamide fibres (PPTA fibres) are classical Kevlar®29. The compound yarn will further be denoted as DREF yarn. The fibres used have the characteristics described in Table 1. The diameter of the wool fibres was determined using a Fibre Fineness Meter (Air Flow) [2], and the linear density of PPTA fibres by using a Vibroskop [3]. We measured the fibre length on a Wira Fibre Diagram Machine [4].

Table 1. Characteristics

	Diameter of fibres, µm	Length, mm(1)	Count of core yarn, tex	Count of sliver, ktex	Percentage of PPTA in DREF yarn, %
Wool	21.60	56		4.6	
PPTA (Kevlar® 29)	12.61	91.8	14.3 21.4 35.7	3.0	20 30 50

(1): Length, in mm: the mean fibre length deduced from the proportions, in terms of count, of the fibres in the sliver.

2.2 Spinning process

In this study, we produced DREF yarns with a count of 71 tex and with variable amounts of PPTA fibres added (20, 30 and 50 wt.-%).

The spinning principle we used is a non-conventional spinning process called DREF [5]. The DREF 2000 apparatus is composed of a rotating carding drum which opens the slivers into single fibres, and a specially designed inlet system being used for sliver retention. The fibres are then stripped from the carding drum by centrifugal force and carried into the nip of the two perforated spinning drums. The fibres are subsequently twisted by mechanical friction on the surface of the drums, which rotate in the same direction (S or Z). The process is assisted by air suction through the drum perforations.

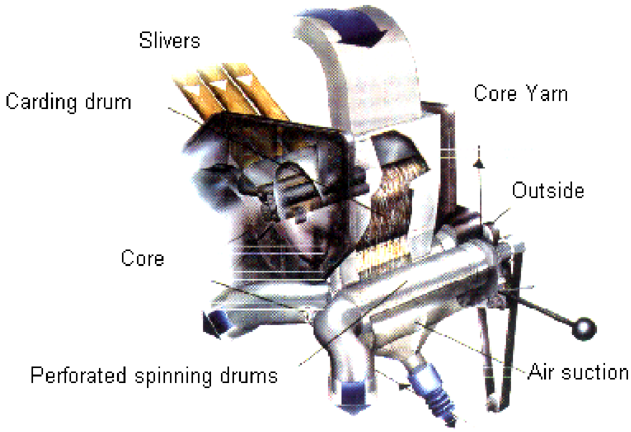

Figure 1. DREF principle

The fibres, which form the slivers used in this process, had a maximum length of 60 mm. The experimental conditions were as follows: production speed of 60 m/min, spinning drum speed of 2500 rev/min and pressure of -45 mbar.
The yarn obtained was a core yarn. The core was a Kevlar yarn, coated by wool fibres to protect the Kevlar against UV.

2.3 Knitting process

The DREF yarns were knitted on an automatic rectilinear machine gauge 7 – Shima Seiki SES 122 FF. The texture used was a double woven rib (the samples had a specific weight of 1.0 ± 0.05 kg/m²).

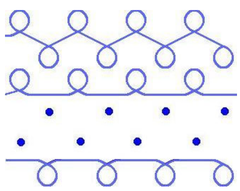

Figure 2. Double woven rib knitted with DREF yarns

2.4 Cutting resistance

The cutting resistance of the knitted articles was tested on a COUPTEST [6] according to the AFNOR standard EN 388-1994. A cutting index "I" was obtained.
Each sample was tested 10 times in two different sequences of 5 tests.

2.5 Cone calorimetry by oxygen consumption

The samples were exposed to a Stanton Redcroft Cone calorimeter at a heat flux equalling 75 kW/m². This flux corresponds to flashover conditions [7, 8], chosen because of the high fire performance of our fabrics. With a lower heat flux, the samples would not have burned. The samples were placed between two cut steel sheets. The surface exposed to the external heat flux measured 9×9 cm². Our method did not correspond to any standard. The conventional data obtained were Rate of Heat Release (RHR) and Volume of Smoke Production (VSP) [9], using software developed in our laboratory. The experiments were repeated 3 times. When measured at 75 kW/m² flux, RHR and VSP values were reproducible to within ±10%. The cone data reported in this work wasis the average of three replicated experiments.

3. RESULTS AND DISCUSSION

a- Cutting resistance

The DREF yarns had variable amounts of PPTA (20, 30 and 50 wt.- %), they were knitted on a double woven rib given in Figure 2. The fabrics then made had almost the same specific weight and thereforecould be compared.

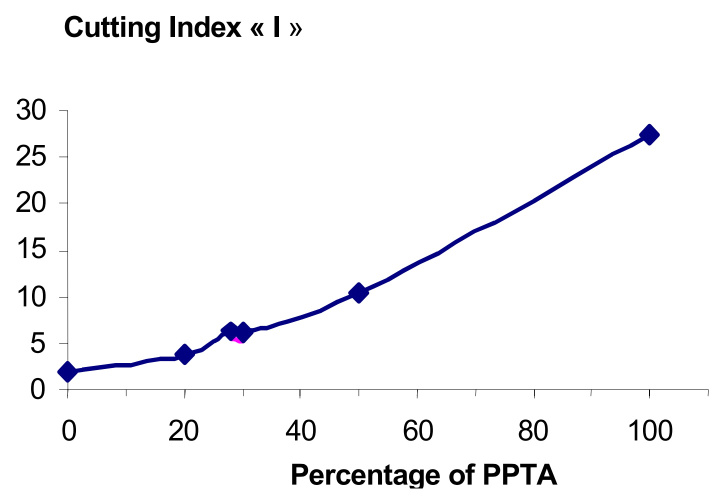

Figure 3. Cutting performances of DREF yarns

Figure 3 shows the cutting behaviour of the knitted fabrics. We observe that the cutting index is about 10 for the samples wool/PPTA 50/50, which represents a very good potential. The standard establishes a classification in 5 levels (1 to 5) and the passage from class 4 to 5 is equivalent to an increase cutting index of 20 [10]. In this case, only Kevlar® could pass to the 5th class. The sample in 50/50 wool/PPTA exhibited a cutting resistance of close to the 4th level, followed respectively by wool/PPTA 70/30 (3rd level), wool/PPTA 80/20 (2nd level) and wool (1st level).

b- Flame resistance of DREF yarns

The fire performance of the wool/PPTA blends increased as the amount of PPTA increased (Figure 4). It can be observed that the RHR peak of wool/PPTA 50/50 blend is slightly higher than the one obtained with PPTA alone, but the time to ignition is lower than with PPTA alone and corresponds to the one obtained with wool [11].

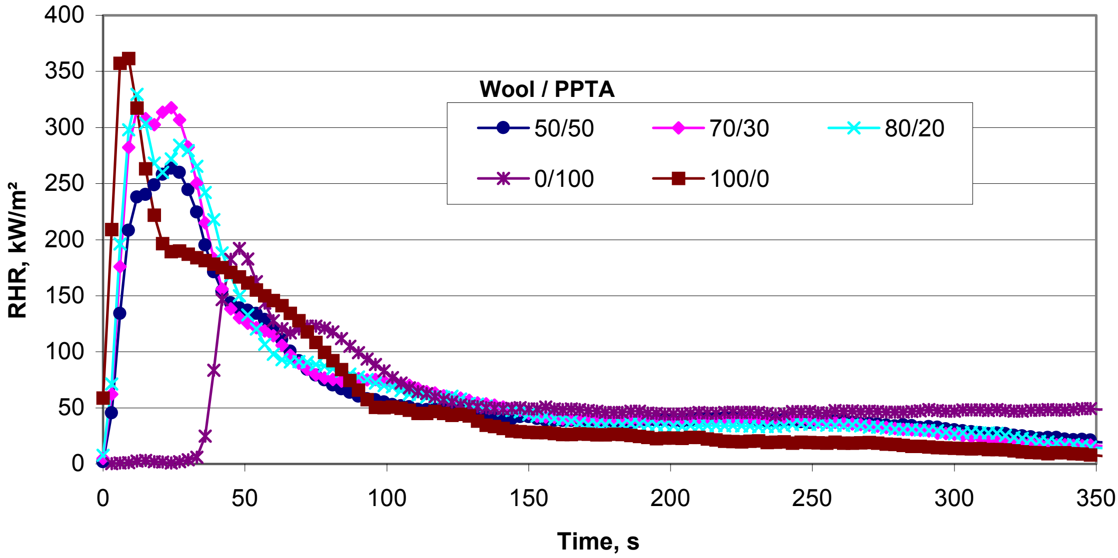

Figure 4. RHR curves of blends wool/PPTA (external heat flux = 75 kW/m²)

The RHR curves of the blends exhibit a double RHR peak, corresponding to the peaks of wool and PPTA respectively [12]. The last RHR peaks always occur at the same time (about 25 s) whatever the composition of the blend. This result suggests that interactions take place between wool and PPTA during fire degradation.

c- dyeing tests

The advantage of DREF yarns (core yarn), is the covering of PPTA by wool. The wool protects PPTA against UV (PPTA is easily degraded by UV), and it is possible to dye the wool with colours and design according to the requirements of the manufacturer.

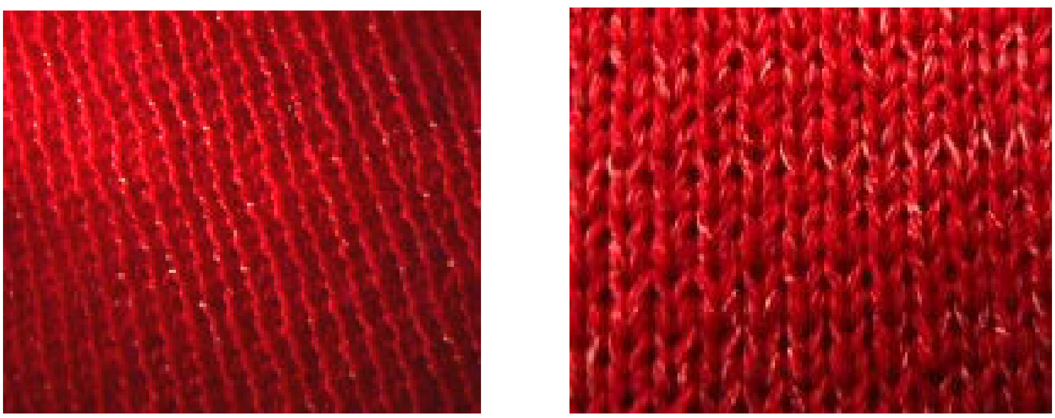

Figure 5. Dyeing samples wool/PPTA 80/20 and wool/PPTA 50/50

The knitted articles were dyed with an acid dye. We may note in Figure 5 that we obtain a good dyeing of fabrics, irrespective of the percentage of PPTA, although some yellow spots are visible due to bad wrapping of PPTA fibres.

d- Spectro-photocolorimeter tests

Spectro-photocolorimeter tests were carried out on knitted articles before and after ageing in a Xenotest apparatus, using a xenon-arch lamp as a light radiation to simulate natural sunlight. The samples were exposed for 100 hours. The results show that the loss of colour shade is reduced by 3 times for knitted structures with DREF yarns in comparison to a PPTA fabric.

3. CONCLUSION

This work shows that the knitted structure of our wool and Kevlar® compound yarns allows fire resistance performance to be improved. The cutting performance increases when the proportion of Kevlar® increases; knitted structures with DREF yarns are better than pure wool. The articles made from compound yarns also show a better resistance to UV, contrary to an article of Kevlar® only. The wrapping of Kevlar® fibres with the wool fibres protects the aramide fibres against UV. Finally, wool can be more easily dyed than Kevlar fibres, allowing a greater range of colorations for the articles produced.

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