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COMPOUND YARNS FOR LONG HEMP FIBERS VALORIZATION

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Abstract: *Due to the high linear density, low elongation and flexibility, hemp fibers cannot be processed to obtain very thin yarns for value-added destinations. In order to increase the spinnability of these fibers, different processing techniques have been tried. The experiments aimed at the development of compound yarns obtained from hemp fibers blended with modified polypropylene fibers and core from different types of filament yarns: silk, viscose and polyester. Compound yarns combine in an efficient way the advantages of wrapping fibers as well as those of core filaments so that they can lead to obtaining textile materials with high tenacity, resistance to abrasion, reduced shrinkage, color resistance, low pilling and good drapeability. The insertion of filaments into the yarn structure has considerably improved the physical-mechanical properties of compound yarns. The coefficient of variation of the breaking force decreases by 29,6% in the case of the compound yarn with silk filaments core compared with the yarn made of 50% hemp/50% modified polypropylene fibers, and the elongation at break of the compound yarn with silk filaments increases by 30.9% compared to the elongation of the 50% hemp/50% modified polypropylene fibers yarn. This hemp type yarns with a linear density of 50 tex are suitable for use in order to obtain fabrics with a specific appearance of textile materials obtained from 100% hemp, but with a reduced mass per surface unit, thus expanding the field of use of long line wet spun yarns*.

Key words: *hemp, wet spun yarns, modified polypropylene fibers, silk filaments*

1. INTRODUCTION

Ecological considerations have become important factors in the processing of textile products. The fibers obtained from hemp stems, which do not require fertilizers and pesticides for growth, meet these requirements and, as a result, have recently aroused the interest of growers and processors [1,2]. For example, in Europe, the production of hemp plants increased in 2018 compared to 2013 by 70% [2].

Hemp fibers are recyclable, biodegradable, cheap and increasingly available. Mainly due to their very good physico-mechanical properties, such as strength and modulus of elasticity [3], ropes, technical fabrics or reinforcements for polymer composite materials can be obtained from these fibers [4-7].

Hemp fibers also have other qualities, such as the ability to absorb sweat and at the same time confer the feeling of coolness, resistance to wear, shine, dye affinity, qualities that make it usable in the clothing industry as well. Clothing products made from hemp fibers have greater resistance and durability than those made from cotton. In addition, hemp has very good antibacterial properties, exceeding those of other natural fibers, and is hypoallergenic, being suitable for clothing worn by people with sensitive skin [8].

Due to the high linear density, low elongation and flexibility, hemp fibers cannot be processed to obtain very thin yarns with diversified destinations. In order to increase the spinnability of these fibers, different processing techniques have been tried, such as that of processing long hemp fibers blended with other natural and synthetic fibers.

Another technology that can be applied is the one that obtains compound yarns or core-spun yarns with combined properties that capitalize on the advantages of the two categories of fibers. Compound yarns have a central core and a second layer of fibers wrapped around it that are tightly integrated so that the fibers do not slip during further processing [9,10].

Recently, considering various destinations, researchers have realized and analyzed different categories of compound yarns, such as yarns for underwear and socks with a polyester core and wrapping antibacterial fibers, yarns with good elasticity obtained from polyurethane core and wrapping nylon fibers, three-component yarns obtained from cotton/polyester/cashmere or acrylic/Tencel/cotton [9], helical auxetic yarn developed from combination of Kevlar and polypropylene or Kevlar and nylon [11], sewing threads with a polyester core and wrapping cotton fibers [12], compound yarns with a worsted core of mercerized wool [13], and many others.

2. MATERIALS AND METHODS

The experiments, the results of which are presented in this work, aimed at the creation of compound yarns obtained from hemp fibers blended with modified polypropylene fibers and core from different types of filament yarns.

The compound yarns were made by wet spinning the roving obtained from the fibrous blend of 50% hemp / 50% modified polypropylene fibers (MPP) in order to improve the dyeing capacity of the fibers. A filament feeding device was mounted on the wet ring spinning machine which allowed spinning the roving fibrous mixture together with different types of filament yarns. For a first variant of compound yarn, degummed natural silk filaments with doubling 3, with a linear density of 2.3 Tex, a tenacity of 22.1 cN/tex and a relative elongation at break of 16.2% were used as a core. Natural silk has high fineness, high tensile strength, extensibility, smoothness and good dyeability [14]. Although it is perceived as having a high price, in recent years consumption has increased and natural silk fibers have become more accessible.

Considering the fact that the natural silk in the yarn composition could increase its price, making it less attractive, despite its advantages, it was tried to replace it with other less expensive filaments, such as viscose or polyester filament yarns.

The second series of tests was performed with viscose filament core as a replacement for natural silk, with a linear density of 11 tex, a tenacity of 10.8 cN/tex and an elongation at break of 11.6%. Viscose has a shine and can be dyed easily, giving the products comfort, softness and breathability.

The third series of tests was carried out with polyester filament yarn core with a linear density of 8.8 tex, with a tenacity of 34.2 cN/tex, with a relative elongation at break of 24.5% and with a twist of 742 twists per metre. The polyester filaments are resistant, elastic and recover well after being subjected to stress.

Yarn breaking force and elongation were determined according to ISO 2062. To obtain the breaking tenacity of the yarn samples, the value recorded for the breaking force was divided by the linear density of the yarn sample. To determine its value, after breaking, the yarn sample that was loaded between the grips of the tensile testing machine was cut at the edge of the grips and then weighed. The obtained value was divided by the initial gage length of 0.5 m. To carry out the experimental determinations, the devices and equipment from the Department of Engineering and Design of Textile Products were used (Tinius Olsen H5KT tensile testing machine, Optika trinocular microscope, precision analytical balance).

3. RESULTS AND DISCUSSION

The three categories of yarns tested were analyzed compared to a classic spun yarn, coreless, made of 50% hemp/50% MPP. In Fig. 1, the longitudinal aspect of this thread can be seen. In the case of compound yarn, the core filament is not visible because the staple fibers of hemp and MPP migrate around the core filament during spinning.

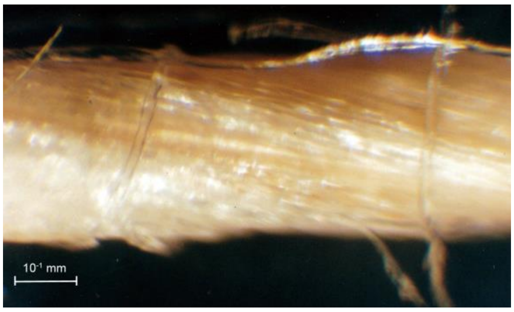

Fig. 1*: Longitudinal morphology of a 50% hemp 50% MPP spun yarn (x150 magnification)*

In Fig. 2, some tensile characteristics of the yarn obtained from 50% hemp/50% MPP and the core yarn obtained by spinning the roving from 50% hemp/50% MPP, together with three filaments of degummed silk, are presented.

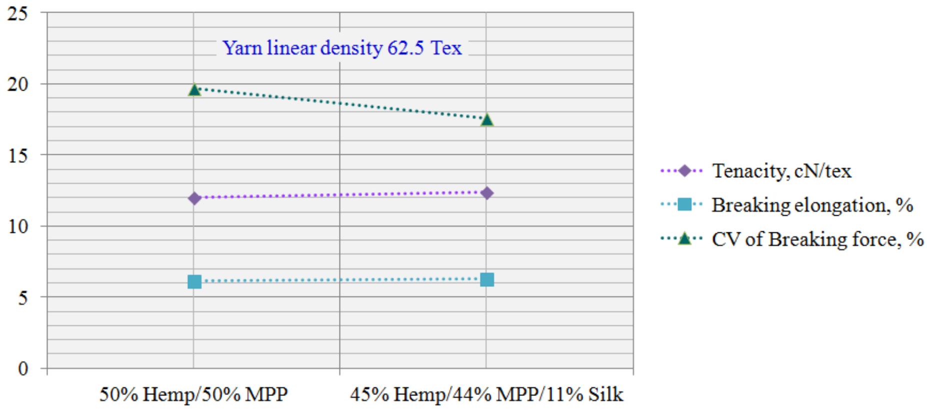

Fig. 2*: Comparison between the tensile characteristics of the yarn obtained from 50% hemp/50% MPP and the compound yarn with silk filaments*

Analyzing the characteristics presented in Fig. 2, it can be found that:

- the breaking tenacity of the compound yarn with silk filaments increases slightly by 3.4% compared to that of the 50% hemp/50% MPP yarn;

- the coefficient of variation of the breaking force decreases from the value of 19.7% for the yarn made of 50% hemp/50% MPP, to the value of 17.6% for the yarn with silk filaments core, i.e. by 10.7%, which constitutes a major improvement to this feature;
- the elongation at break of the compound yarn with silk filaments increases by 2.9% compared to the elongation of the 50% hemp/50% MPP yarn.

The number of yarn breaks recorded when machine processing the silk filaments together with the hemp/MPP blend was lower than that observed when spinning the yarn from 100% hemp. Since through these experiments it was aimed to lower the limit of the linear density of hemp-type yarns that are currently being produced, attempts were made to obtain 50 tex compound yarn with a core of silk filaments.

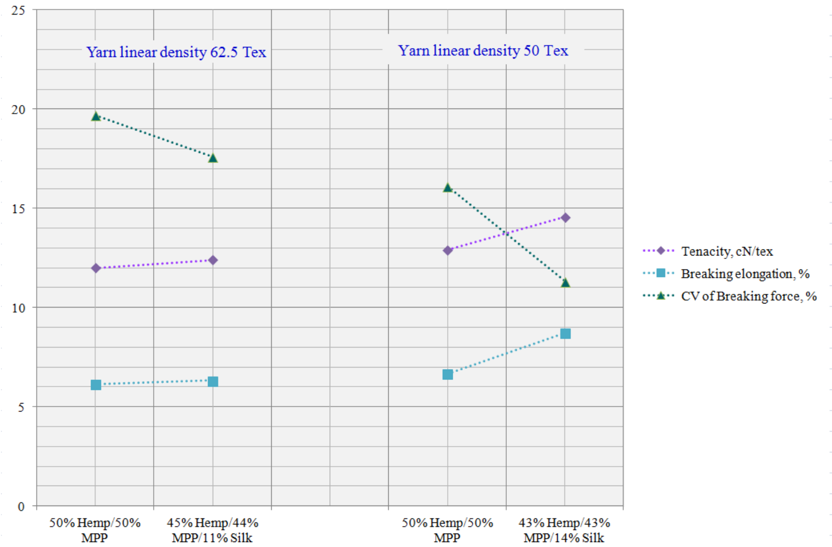

Fig. 3*: Comparison between the tensile characteristics of the compound yarns with different values of linear density obtained from hemp/MPP/silk filaments*

Analyzing the graphs presented in Fig. 3, it can be seen that all the tensional characteristics have kept their increasing or decreasing tendencies, and these tendencies are much more obvious in the case of the thinner yarn. Thus, in the case of the yarn with linear density of 50 tex, the breaking tenacity of the compound yarn with silk filaments increases by 12.7% compared to that of the 50% hemp/50% MPP yarn, the coefficient of variation of the breaking force decreases by 29,6% in the case of the compound yarn with silk filaments core compared with the yarn made of 50% hemp/50% MPP, and the elongation at break of the compound yarn with silk filaments increases by 30.9% compared to the elongation of the 50% hemp/50% MPP yarn.

Analyzing comparatively the tensional characteristics of the yarns shown in Fig. 4, it can be found that the tenacity values, if the core is made of viscose and polyester filaments, are lower by 24.1% and by 11.7%, respectively, than those of the yarn that has natural silk in the composition, although the polyester filament yarn, analyzed individually, has a higher tenacity than natural silk filaments. There is a difference between the percentages of silk and polyester filaments in the mass of composite yarns. Since the percentage of silk core filament in the compound yarn mass is lower compared to the polyester core, it can cause more winding of the strong hemp and MPP fibers than in the case of the polyester core, thus resulting in a higher strength value of the compound yarn with silk core. In addition, the fact that the polyester filaments are twisted appears to negatively influence the processing of the fibers and the characteristics of the compound yarn. If the twisting direction of the compound yarn is the same as the twisting direction of the polyester filaments, during spinning, an over-twisting of the polyester filaments may occur, which leads to a weakening of the resistance, and if the twisting directions are different, a de-torsion of it occurs, which causes the decrease of his resistance.

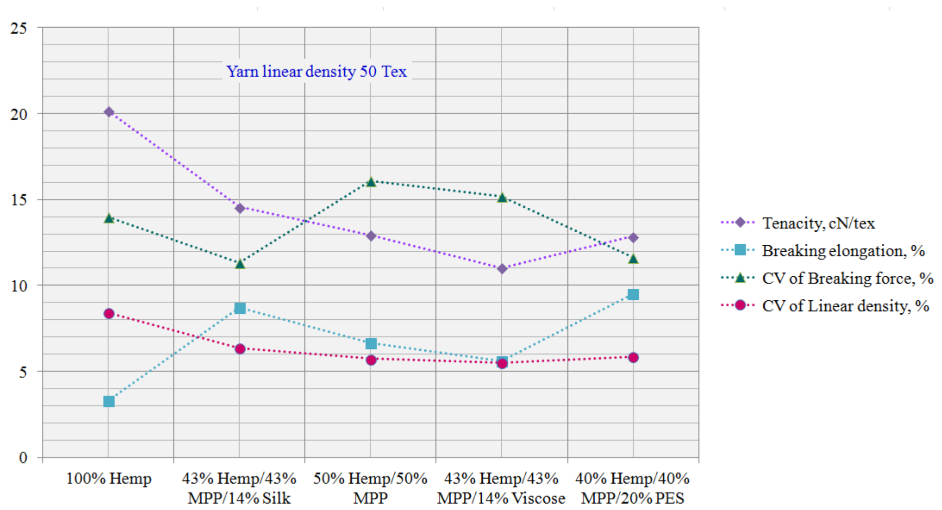

***Fig.** 4: Comparison between the tensile characteristics of the compound yarns obtained from hemp/MPP/silk filaments, hemp/MPP/viscose, hemp/MPP/polyester*

As shown in Fig. 4, the elongation at break of hemp/MPP/viscose yarn is 35.5% lower than that of hemp/MPP/natural silk yarn and 40.9% lower than that of hemp/MPP/polyester yarn but all are much higher than the breaking elongation of 100% hemp yarn. The most spectacular increase, by 187%, of the elongation at break is recorded in the case of the yarn with a polyester filament yarn core.

For the compound yarn that has viscose in its composition, the coefficient of variation of the breaking force is higher than the coefficient of variation of the other compound yarns analyzed. These data make the yarn with viscose filament yarn core to be considered less advantageous compared to the other yarns containing natural silk or polyester.

Comparing the previously analyzed yarns and the yarn resulting from spinning the hemp/modified polypropylene roving, it was found that the tenacity of the polyester core yarn is close to that of the 50% hemp/50% MPP yarn. The tenacity of hemp/MPP/natural silk yarn is 11.2% higher than that of the bicomponent yarn. Also, the elongation at break increases by 23.6% by introducing natural silk into the yarn and decreases by 15.6% by the presence of viscose in the yarn.

Regarding the coefficients of variation of the linear density of the yarns, no relevant changes were found in them by introducing the filamentary yarn core into the yarn.

4. CONCLUSIONS

The presence of the filament in the compound hemp type yarns makes it possible to obtain yarns considered thin for flax and hemp industry, yarns with good physical-mechanical characteristics and with greatly improved elongations. As for the elongation values, they approach or even exceed those of semi-combed wool yarns, of the same fineness, which represents a gain for yarns that have hemp in the composition.

Hemp type yarns with a linear density of 50 tex are suitable for use in order to obtain fabrics with a specific appearance of flax or hemp type fabrics, but with reduced mass per surface unit.

Their main advantage, however, remains the fact that they can constitute an alternative in the range of new threads that respond to the constant innovation required by the change in aesthetic aspect of clothing products.

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