Processing of hemp fiber in blends with cotton for apparel fabrics

R. Kozlowski, J. Mañkowski, W. Cierpucha, A. Kubacki and M. Muzyczek
Institute of Natural Fibers, Poznan POLAND
Correspondence author jorge@inf.poznan.pl; sekretar@inf.poznan.pl

ABSTRACT

The paper presents results of trials on the manufacture of hemp-cottonised fiber from different types of hemp fiber (hemp tow, hemp homomorphic fiber, hemp oils). The technical and technological conditions of hemp fiber processing into hemp cottonised fiber are presented as well as qualitative parameters of the fiber, which was used for spinning in a blend with cotton. The studies described in this paper cover cotton-hemp blends and spinning on a pneumo-mechanical cotton system. The trials resulted in yarn containing 20-30% hemp and linear density of 80-84 tex. The yarns were used for manufacturing apparel fabrics with a weight of 310 g/m^2. The fabrics were used for the preparation of a ladies' fashion collection.

Introduction

Flax and hemp are plants which cultivation and processing have a centuries-long tradition. Alongside wool and silk, the two fibers are a natural renewable source of textile raw material that can be produced, processed and utilized in Poland. This makes Poland independent, to some extent, of vacillations in the world market and provides a stock of strategic textile raw materials for the country.

The following conditions predispose Poland to produce flax and hemp:

- Favorable soil and climatic conditions.
- Adequate level of agricultural science and skill and tradition of the farmers as well as availability of the processing industry.
- A high breeding level of the indigenous varieties of flax and hemp.
- An active and efficient research and development center.

Cultivation of the fibrous plants is also advocated by:

- The wide range of the possible products, including fiber, seed, shove, woven and knitted fabrics, oil, fodder, food, medical products, paints, and materials for composite products.
- The ecological purity in all phases of processing plus the possibility of re-use of the worn out products.
- The possibility to use these plants for re-cultivation of land degraded by industry or automotive traffic.

Rapid development is also taking chance in non-textile uses of flax and hemp as an annually renewable source of raw material for many sectors of industry, including the pulp-and-paper industry, transport, building industry (composites), etc.

The creation of national markets for flax-based products is a current practice in many countries, e.g. the Scandinavian countries, which are regarded as leading in the protection of health and environment.

What is more, the production based on flax and hemp has a 'niche' character in the sense that it does not collide with other EU products, while offering a considerable number of jobs in agriculture and industry, which is particularly important considering the present over-production of food in Europe.

Among the most important advantages of the hemp fibers are:

- High hygroscopicity and rapid transport of moisture, and air-permeability.
- High value of wetting heat, which facilitates adaptation of the body to variable ambient conditions.
- A cool 'hand' (feel to the touch) that is particularly noticeable under conditions of high ambient temperature.
- A high breaking strength that can improve the durability of the end product.
- Freedom from generation of electrostatic charges, an important property of clothes used in working on electronic devices.
- A high protective capability against UV radiation (lignin content from 3.5 to 5.5%), which is very important when living in a hot climate and – due to the ozone hole – also in a moderate climate.
- No allergic action on the human organism, plus natural bateriostatic and fungistatic properties.
- Favorable physiological interaction, as mentioned earlier.

On the other hand, the two fibers have a number of disadvantages as viewed from the point of processing, especially spinning, including, the following:

- Substantial coarseness and irregularity.
- Stiffness.
- Low elongation at break.

These features adversely affect spinning speed and make spinning difficult. Due to their specific structure (polycellularity, polymorphism), flax and hemp fibers are mainly processed into yarn on the conventional linen spinning system. Compared to other spinning systems this conventional technology is more labor intensive, less productive and less effective economically. Hence the tendency to modify these fibers so as to enable their processing on other than flax-processing machinery, e.g. machinery belonging in the cotton and wool spinning systems. Here, mechanical modifying treatment is often supplemented by a biochemical treatment (enzymes).

Adaptation of hemp fiber to spinning by the cotton rotor-spinning system

In nature, flax and hemp occur in the form of so-

called 'ultimates' (elementary fibers) glued together by pectinous gums into aggregates often referred to as technical fibers. This makes the fibers distinct from the unicellular fibers such as cotton. The specificity of the technical flax or hemp fiber consists in that, in its processing into yarn the aggregates are separated into smaller bundles of ultimates. The degree of separation of the technical fiber is dependent on the adopted spinning technique used (dry spinning or wet spinning possibly combined with biochemical or chemical treatment in roving form).

The remaining physical parameters of the flax and hemp ultimates resemble those of cotton. Hence the possibility of blending these fibers, after suitable modification, with cotton, wool or manmade fibers. In practice, satisfactory results have been achieved as regards adaptation of flax to the cotton and wool systems. Considerably less research, however, has been carried out on the cottonising of hemp.

In this paper are presented the conditions and results for:

- Production of cottonised hemp fiber obtained from dual-purpose grown hemp (grown for seed and fiber) and single-purpose grown hemp (grown for fiber).
- Production of blend yarns of linear density from 80 to 100 tex (cottonised hemp content from 20 to 30 percent).
- Weaving and finishing of an apparel fabric.

Characteristics of investigated hemp fiber

The following types of hemp fiber were investigated (Table 1):

- Tow from water-retted hemp grown for seed and fiber.
- Monotype fiber from dew-retted hemp grown for seed and fiber.
- Monotype fiber from dew-retted hemp grown only for fiber.

Conditions of the cottonising process and properties of the cottonised hemp fiber

The experiments with cottonising were carried out in the two directions:

- Production of cottonised hemp by mechanical treatment of the fiber.
- Production of cottonised hemp by chemical treatment of the fiber.

In the producing of mechanically cottonised fiber the following operations were employed:

- Breaking of tow or fiber in two passages;
- Emulsifying and seasoning;
- Formation of lap;
- Carding;
- Cutting of card sliver into 40 mm segments;
- Carding of the cut sliver in one or two passages (on a card adapted for hemp by the Institute of Natural Fibers, Poznan).

Fibers

The chemically cottonised hemp (hemp tow) was produced in a similar way to the mechanically cottonised hemp, except that the card sliver was cut into 60 mm segments. The latter was scoured in a solution of soda lye, acidified, rinsed, centrifuged, dried and subjected to two passages on a CS611 card.

In the cottonising process (Table 2), the finest hemp fiber, 2.15 tex, was obtained from monotype fiber produced from a single-purpose grown hemp (densely sown and early harvested). Following the chemical treatment, the fiber from the dual-purpose grown hemp attained a fineness of 2.66 tex.

Spinning conditions and quality of the yarn

The hemp content of a blend (20%, 25% or 30%) was planned depending on the fineness of the hemp fiber and its delicateness and softness. The mechanically cottonised hemp fiber with fineness between 3.1 and 4.5 tex was used in blends containing 20% hemp. The chemically cottonised hemp fiber, of fineness 2.66 tex, was used in a blend with a hemp content of 25%, and the finest, mechanically cottonised fiber, 2.15 tex, from single-purpose grown hemp was used in a blend with a hemp content of 30%. For blending with the coarser cottonised hemp fiber, higher-quality long cotton, 34/36, was used. In the remaining cases, cottonised hemp was blended with short-fiber cotton 31/32 (Table 3).

The spinning process was carried out as follows:

1. Emulsifying of cottonised hemp in a water solution of wax in a ratio of about 5% to fiber mass till moisture content of the blend was about 15%.
2. Conditioning of cottonised hemp for 24 to 48 hours.
3. Opening of the cotton/hemp blend (formed in adequate proportion by weight) on a willow at a constant humidity of 80% and temperature of 18 °C.
4. Seasoning for 48 hours with manual displacing every about 8 hours.
5. Formation of lap on a picker and storage in a bunker before supplying to the carding room.
6. Formation of card sliver.
7. Sliver doubling on first draw frame.
8. Sliver doubling on final draw frame.
9. Spinning on a BD200 rotor-spinning frame.

The spinning process was acceptable in all trials and breakage in spinning was also at a level acceptable for cotton yarn. The quality parameters of the yarn can be regarded as good (Table 4).

Use of cotton-type yarn made with a content of cottonised hemp for manufacture of woven apparel fabrics

Trial weaving

For the weaving trial a cotton-type as-spun single yarn 84 tex composed of 80% cotton and 20% single-purpose grown hemp was used. A woven apparel fabric, designated as Art. 4236, was made on an STB loom according to the specifications given in Table 5.

Finishing of the woven fabric

The following finishing operations were carried out:

1. Shearing (Textima shearing machine).
2. Singeing.
3. Washing (OMEZ open-width 8-section washing machine, Roksol – 2g/l at boiling temperature).
4. Softening and antishift agents (low-formaldehyde resin, silicone softener, antishift agent) .
5. Drying (Babcock stabilising dryer).
6. Sanforising (Maskrop sanforiser).

The fabrics were un-dyed. The results of the laboratory tests (physical analysis) of the finished fabrics are presented in Table 6. In all phases, the process of manufacturing the apparel cloth from yarn containing 20% hemp was smooth and uneventful. Upon inspection, the quality inspectors of the Linen Factory, Zyrardów, ranked the fabrics in the First Quality class. The fabric had good laboratory test results, and owing to the finishing operations, it was relatively soft and had an interesting texture. The fabric is suitable for articles of clothing, such as jackets and trousers.

Conclusions

1. The experiments involving the modification of the hemp fiber for spinning in blends with cotton, showed the possibility of producing a cottonised hemp fiber that could be used together with cotton in proportion from 20% to 30% for the manufacture of a cotton-type rotor-spun yarn of a linear density from 80 to 84 tex.

2. The proportion of cottonised hemp in a blend depends first of all on the fineness of the cottonised fiber, the latter being a function of the type and character of the input raw material and cottonising technology employed. Finer and more delicate fibers are obtained if cottonising is supplemented with chemical treatment (chemically cottonised fiber) and if the fiber comes from single-purpose grown hemp (densely sown and early harvested).

3. The results of weaving trials on the cotton-type hemp-containing yarn confirmed its use for apparel fabrics ideally suitable for summer clothes, the more so, as such fabrics are characterized by a cool feel, excellent air-permeability, good hygienic properties, and substantial resistance to UV radiation.

The presence of hemp fiber ensures the comfort of clothes, satisfying the requirements of clothes designed to be worn under conditions of high temperature, high insulation (solar radiation) or strong magnetic fields often occurring in today's mechanized and computerized environments.

References

- Cierpucha, W. and Mańkowski J. (2001). New Technologies of Hemp Cottonised Fiber Production and it's Proccesing in Textile Industry. Proceedings of the Second Global Workshop Bast Plants in the New Milleniunm, Borovets.
- Cierpucha, W., Mańkowski, J. and Rynduch, W. (1999). Konopie jako surowiec do produkcji kotoniny. Fibers & Textiles in Eastern Europe, Lodz.
- Czekalski, (1998). Manufacturing Hemp – Containing Union Yarns by the Cotton System. Proceedings of 7th International Conference, ¯yrardów.
- Mańkowski, J. and Rynduch, W. (1996). The Cottonised hemp fiber as a blend component in yarns. Proceedings of the 4th European Regional Workshop on Flax, Rouen.
- Mańkowski, J. (1999). iinni – Technologia produkcji i kotoniny konopnej bawe³nopodobnej i we³nopodobnej. *Natural Fibers,* **XLIII**.

Table 1. *Characteristics of the hemp fiber.*

Type of fiber	Mean fiber length (mm)	Fineness of fiber (tex)	Impurity content (%)
Water-retted hemp tow from so-called dual-purpose grown hemp.	297.0	10.6	2.8
Dew-retted hemp fiber from so-called dual-purpose grown hemp	143.2	9.52	2.1
Dew-retted hemp fiber from so-called single-purpose grown hemp	157.0	3.0	1.5

Table 2. *Physical properties of the cottonised hemp fiber.*

Type of fiber	Type of cottonising treatment	Mean fiber length (mm)	Fineness of fiber (tex)
Water-retted hemp tow from dual-purpose grown hemp	Mechanical	34.3	3.15
	Chemical	37.4	2.66
Dew-retted hemp fiber from dual-purpose grown hemp	Mechanical	33.0	4.50
Dew-retted hemp fiber from single-purpose grown hemp	Mechanical	27.8	2.15

Table 3. *Spinning blend composition.*

Raw materials		Hemp tow content of blend (%)
Hemp	Cotton	
Mechanically cottonised tow	Long-fiber 34/36	20
Mechanically cottonised fiber from single-purpose grown hemp	Long-fiber 34/36	20
Chemically cottonised hemp tow	Short-fiber 31/32	25
Mechanically cottonised fiber from dual-purpose grown hemp	Short-fiber 31/32	30

Table 4. *Laboratory characteristics of cotton-type yarn containing cottonised hemp.*

Type of cottonised hemp in blend	Cottonised hemp con tent of blend (%)	Linear density of yarn		Variation in linear density (%)	Tenacity (cN/tex)	Variation of breaking load (%)
		Normal (tex)	Actual (tex)			
Mechanically cottonised tow	20	84	85.5	2.4	9.66	13.2
Mechanically cottonised fiber from single-purpose grown hemp	20	84	79.7	2.7	7.40	18.2
Mechanically cottonised fiber from dual-purpose grown hemp	30	80	79.0	3.2	8.19	18.1
Chemically cottonised hemp tow	25	80	81.2	3.1	8.2	16.2

Table 5. *Specifications for hemp-containing apparel fabric, unfinished.*

		Value
Fabric	Width	156.0 ± 2.5 cm
	Reed width	166.0 cm
Warp	Warp yarn, Hemp (20%)+Cotton (80%)	84 tex
	List yarn, dyed, unfinished	40x2 tex
	Number of ends	2368±2
	Sett	153±3 per 1 dm
	Take-in	1.05
	Linear mass	208.9±2.1 g/m
	Consumption	216.4±2.2 g/m
	Waste	3.5%
Weft	Weft yarn, Hemp (20%)+Cotton (80%)	84 tex
	Sett	170±5 per 1 dm
	Linear mass	274.1 g/m
	Waste	4%
Fabric	Linear mass (running meter)	435±22 g/m
	Surface mass	279±g/m2

Table 6. *Specifications of hemp/cotton apparel fabric, finished.*

		Value
Width		145.0 ± 2.5 cm
Linear mass		449.0 ± 36 g/m
Surface mass		310.0 ± 25g/m^2
Number of threads	Warp	165 per 1 dm
	Weft	166 per 1 dm
Tex of yarn	Warp	85.4
	Weft	85.1
Take-in of yarn	Warp	1.074
	Weft	1.061
Dry breaking strength	Warp	56 daN
	Weft	58 daN
Elongation at break, dry	Warp	11%
	Weft	16%