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Using Unretted Flax to Obtain Yarns and Woven Fabrics

Abstract

The paper discusses the optimisation of some of the working parameters in the processes of extracting and manufacturing unretted flax fibres to eliminate impurities and attain a certain degree of fibre fineness and mean length in the flax yarns obtained. Unretted flax yarn is obtained by a new wet spinning system with a twister tube. This yarn has a new structure, and so its fibres are located parallel to the yarn axis. Yarn strength is determined by recovering the link substances after drying. Their low strength recommends these yarns for woven fabrics processed on machines with medium weaving speed.

Key words: yarn, unretted flax, carding degree, wet spinning.

Introduction

The great popularity flax has enjoyed during the whole history of mankind is by the mechanical, physical and aesthetic properties of these products, as well as those characteristics which are specifically adequate for their domain of application [1].

The present competition on the market requires continual improvement of processing techniques for flax fibres and yarns.

Flax fibres as extracted from the flax stems are known to be natural, technical fibres with quite a complex structure, which considerably influences their properties and processing called textile domains. In the case of flax, which is a multi-cells cellulose fibre, many of the specific characteristics are not found in unique natural fibres such as cotton and wool. The characteristics of these individual fibres (cotton and wool) are reflected, with a few differences in the yarn. The length and fineness of the flax fibres are modified at every stage of the classical spinning process. Shortening and thickness of the flax fibres are desirable phenomena as long as they occur within imposed limits. The techniques of stem processing and fibre extraction without retting, followed by bleaching the fibres, meet the highest best requirements induced by the development of the flax industry [2 - 4].

Over 80% of the mass of the flax stems consist of the wooden part and other components, all of which must be eliminated. The amount of hemicelluloses, pectin and protein, minerals, lignin, tannins and waxes depends on the climate and soil conditions, applied agrotechnically, as well as the intensity of the fibre extraction from the stems [5 - 9]. Separating the flax fibres from the other organic tissues depends on their different behaviour

under mechanical stresses, such as stroke and shaking.

The high percentage of impurities on the flax fibres extracted from unretted stems (30-50%) demands that solutions to eliminate them be found, because the high content of non-cellulosic materials in the flax fibres has a negative influence on the spinning, weaving and finishing processes.

This paper aims at optimising some of the working parameters of the process of extracting and manufacturing unretted flax fibres for removing impurities, attaining a certain degree of fibre fineness and of their mean length, in the flax yarns which are obtained. The unretted flax yarn is obtained by a new wet spinning system with a twister tube.

Experimental procedure

In the experiments, fibres extracted from unretted stems belonging to the Hera cultivar of the Joseni area (Romania) were used. Experimental programmes with several variants and calculated stages for each variable were applied. The physical and mechanical characteristics are measured according to the standardised methodology. Mathematical methods of dispersion analysis and regression [11 - 13] were applied while establishing the working conditions, assuring an optimum value of the dependent parameters: percentage of impurities, fibre fineness in Nm, average length of the fibres delivered by the carding machine. Next, the yarn was obtained on a new wet spinning system [10] with false twist from sliver processed on the drawing and the roving frames, and then bleached.

Results and discussion

One solution for eliminating impurities in flax fibres extracted from unretted

stems is to use the best working parameters of the extraction and fibre processing equipment. Thus, for stems with 17-18% humidity on entering the dryer, a value of 40 °C will be the recommended air temperature in the conditioning system, and 6 m/min –will be the speed for stem movement in the dryer. It was considered that the level of pressing force on the breaker rollers from the five crush zones on the fibre extraction aggregate greatly influences the amount of impurities remaining on the fibres.

Mathematical modelling of the phenomenon based on the experimental data led to the following equation, which expresses satisfactorily the simultaneous influence of the five independent parameters: press forces on rollers from the crush zones x_1, x_2, x_3, x_4 , pressing force from the pre-crush zone x_5 ; and the resulting characteristic, the percentage of impurities on the unretted flax fibres P_I :

$$P_I = 48 + 0.79x_1 - 2.1x_2 + 2.44x_3 - 2x_4 - 1.13x_5 + 2.25x_1^2 - 2.412x_2^2 + 1.975x_4^2 - 1.238x_5^2 - 1.29x_1x_2 - 2.575x_4x_5 - 1.05x_1 \quad (1)$$

where:

- x_1, x_2, x_3, x_4 - are the pressing forces on rollers from the crush zones, daN;
- x_5 - is the press force from the pre-crush zone, daN;
- P_I - represents the percentage of impurities on the unretted flax fibres.

The influence upon the resulting characteristic of the percentage of impurities (P_I) on the unretted flax fibres by the five independent variables during their simultaneous action is indicated in Figure 1.

Analysis of the five independent variables as influences upon the resulting

characteristic, P_1 (Figure 1), establishes which of the independent variables has the greatest influence upon the percentage of impurities in flax fibres from unretted stems. The constant level curves plotted in Figure 1 may be used to establish the level of the pressing forces exercised on all rollers from the crushing zones, so that a certain level of the percentage of technical flax fibre impurities can be attained.

The maximum value of the fibre impurities is obtained for the version in which the pressing forces exercised on all rollers from the crushing zones are equal among them (6 daN). This combination of the pressing forces corresponds to the centre of the experimental domain, and it is considered as one of the unfavourable working situations on the breaker.

Mathematical modelling and subsequent experimental verification allowed us to establish the optimal limits of the pressing forces in specific zones. In this way, the recommended variation interval for this forces is between 4 and 8 daN, with the following distribution: 8-10 daN in the pre-crushing zone, 8 daN in the first zone, 8 daN in the second, 6 daN in the third zone and 4 daN in the last crushing zone.

Determining the fineness, length, impurities content and strength of flax fibres are essential, because their processing intensity in the spinning mill is established in relation to these properties.

Carding action represents one of the basic processes in spinning mills with the technological carded process or the carded-combed process.

The presence of impurities in fibres is one of the causes of unevenness for half-finished products and yarns. Fibre cleaning is done by the worker and stripper situated under the carding machine at the moment of the fibres' movement. The quantity of impurities eliminated depends on the ratio between the speed of the central cylinder of the card and their inferior workers, as well as the ratio between the speed of the stripper and those of the inferior workers. A high carding degree allows breaking connections between the wooden part and the fibres themselves. A more intense degree of carding increases the probability of removing a greater quantity of impurities from the fibres. The impurities will be eliminated from the mass of fibres during the fibres' transfer from the inferior worker to the returning cylinders.

The cleaning degree g_{cl} and the carding degree g_c are defined by:

$$g_{cl} = \frac{v_{Rinf}}{v_{winf}} \quad (2)$$

$$g_c = \frac{v_T}{v_w} \quad (3)$$

where:

v_{Rinf} - is the velocity of inferior returning cylinders, m/min;

v_{winf} - is the velocity of inferior worker cylinders, m/min;

v_T - is the velocity of the central cylinder, m/min.

During the experiments and the mathematical analysis, the mode of changing some fibres' characteristics from the delivered card sliver under the simultane-

ous influence of the carding and cleaning degrees was followed. The following characteristics were studied: percentage of impurities, fineness, and mean length.

The mathematical modelling equations, based on the experimental data of the specified characteristics for the unretted flax fibres delivered by the carding machine, are as follows:

$$P_2 = 12.205 - 1.174g_{cl} + 0.2211g_c + - 1.58511g_c^2 + 0.0734g_{cl}g_c \quad (4)$$

$$Nm_f = 262.2 + 2.245g_{cl} + - 14.905g_c + 0.7725g_{cl}^2 + - 19.825g_c^2 - 12.57g_{cl}g_c \quad (5)$$

$$l_f = 12.02 + 0.475g_{cl} + 0.369g_c + + 0.624g_{cl}^2 - 0.72g_c^2 + 2.449g_{cl}g_c \quad (6)$$

where:

P_2 - is the total percentage of impurities on the fibres delivered by the card;

Nm_f - is the fibre fineness in Nm;

l_f - is the average length of the card-delivered fibres;

g_{cl} - is the cleaning degree as modified by the changing wheel of the strippers;

g_c - is the carding degree modified by the changing wheel of the inferior workers.

The accuracy of the mathematical models approximated by the above equations is confirmed by differences (under 10%), between the calculated and measured values of the fibres' quality characteristics. The parameters studied were: the quantity of impurities on the unretted flax fibres from the delivered sliver of the carding machine, the fibres' fineness and their average length.

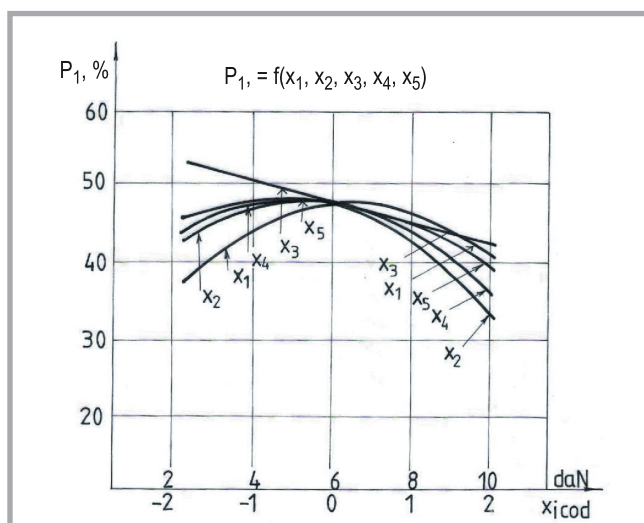


Figure 1. Variation of the percentage of impurities in unretted flax fibres as a function of the pressing forces on the rollers from the five zones of the breaker.

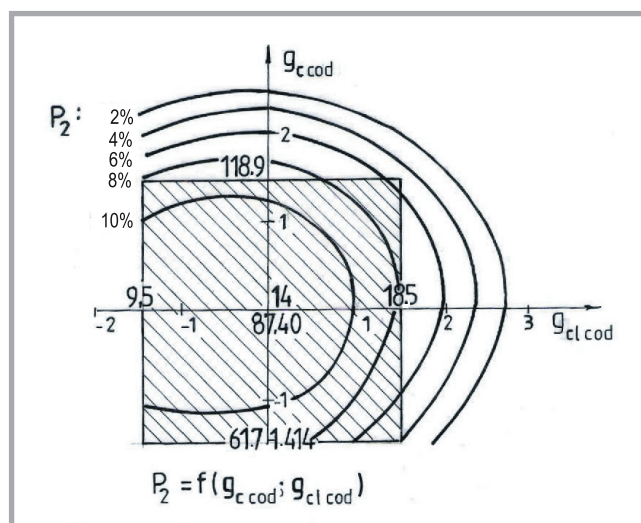


Figure 2. Constant-level curves of the total percentage of impurities in unretted flax fibres in the delivered sliver card as a function of the carding and cleaning degrees.

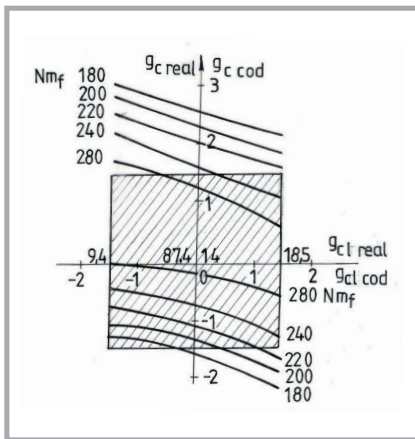


Figure 3. Constant-level curves of fibres fineness from unretted flax by the delivered sliver card as a function of the carding and cleaning degrees; $Nm_f = f(g_{cl\ cod}; g_{c\ cod})$.

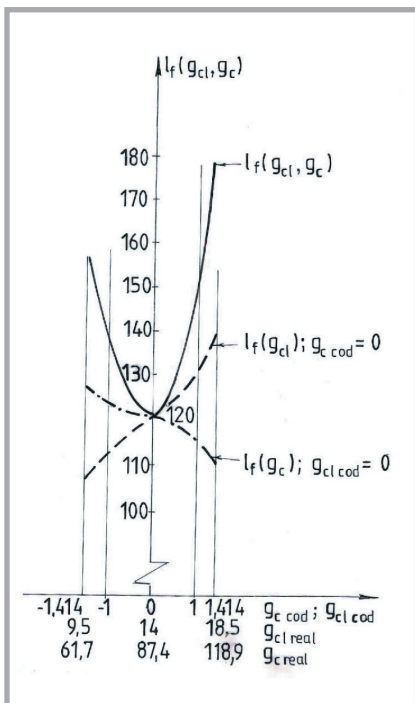


Figure 4. Variation of the mean length of the flax fibres in the delivered sliver card as a function of the carding and cleaning degrees.

The constant-level curves plotted in Figure 2 permit the establishment of the intensity of influence of the two independent parameters under study: the cleaning degree g_{cl} and the carding degree g_c , on the total percentage of impurities in the fibres. The intensity of the influence exercised upon the resulting characteristic – the total percentage of impurities – was studied during the simultaneous action of the two independent variables.

Figure 2 shows that in the experimental interval in which the carding degree reaches values between 62 and 118, and the clean-

ing degree between 9.5 and 14, a greater influence on the percentage of the fibres' impurities is exercised by the carding degree of the first carding group, modified by the inferior worker's wheel. In the 14-18.5 interval for the cleaning degree and 62-118 for the carding degree, the stripper-changing wheel should be modified.

Using the constant-level curves from Figure 3, it is possible to establish the working conditions necessary for obtaining a certain degree of fineness of the unretted flax fibres delivered by the carding machine.

The maximum fineness of fibres delivered by the card with the fibres' length protections of unretted flax is obtained if:

- the carding degree is between 87-108;
- the cleaning degree is between 14-16.

Analysis of the constant-level curves presented in Figure 3 shows that the intervention of one parameter, either the carding or the cleaning degree, favours the action of the other. Consequently, shifting from one level curve to another involves either a higher carding degree or a higher cleaning degree. However, the carding degree influences the increase in fibre fineness to a greater extent, because its lower absolute values determine the shift from one level curve to another.

The constant-level curves plotted in Figures 2 and 3 permit the establishment of the values of the carding and cleaning degrees at which a certain level of the total percent of impurities or fibre fineness from unretted flax is attained.

Dust elimination is very important, because the impurities act as obstacles

which determine fibre breaking during the carding process. Analysis of the curves in Figure 4 plotted from the experimental data and Equation 4 shows that if the carding and the cleaning degrees reach maximum values (118; 18.5), the mean length of the delivered card fibres is the maximum (180 mm).

The intensity of the influence exercised upon the resulting characteristic, the mean length of the flax fibres in the delivered sliver card during the simultaneous action of the carding degree and of the cleaning degree, is expressed in the graph plotted in Figure 4.

The carding process should be progressive to protect fibre length. For this purpose, we recommend working in the first carding group zone, with a carding degree ranging between 80-100 and a cleaning degree between 10-13 (Figure 4).

After sliver processing on the drawing frames, on the roving frame, and bleaching the rove, wet spinning with false twist follows. The equipment is presented in Figure 5.

Table 1 lists the values of the quality characteristics for the yarn obtained by the new spinning system in comparison with the wet spun classic yarn.

With this new spinning system, unretted flax yarn with a new structure, in which the fibres are located in almost parallel with the yarn axis, was manufactured (Figures 6, 7). Yarn strength is determined by the rally of the link substances after drying. Their low strength recommends the use of these yarns for woven

Table 1. Characteristics of unretted flax yarn wet spinning with false twist.

| Characteristics | Yarn with real twist STAS 1717 | Yarn with false twist of the unretted flax |
|---------------------------------|--|--|
| Linear density in tex T_{tex} | 84 | 86.2 |
| Breaking strength, cN | Quality E: 1670 Quality I: 1400 Quality II: 1170 | 967.0 |
| Strength CV, % | 16 | 15.2 |
| Elongation, % | 3 | 2.2 |

Table 2. Characteristics of the new woven fabric compared with the existing one.

| Woven fabric type | | Breaking strength, daN | | Elongation, mm | | Woven fabric thickness, mm | Woven fabric mass, g/m ² | Mass loss, % |
|-------------------|-----------------------------|------------------------|------|----------------|------|----------------------------|-------------------------------------|--------------|
| | | Weft | Warp | Weft | Warp | | | |
| PREDANA | Existing T_{weft} 100 tex | 45.2 | 22.0 | 20.6 | 39.8 | 0.64 | 237.5 | 2.040 |
| | New T_{weft} 86.2 tex | 40.8 | 22.0 | 21.2 | 39.8 | 0.62 | 231.2 | 1.359 |

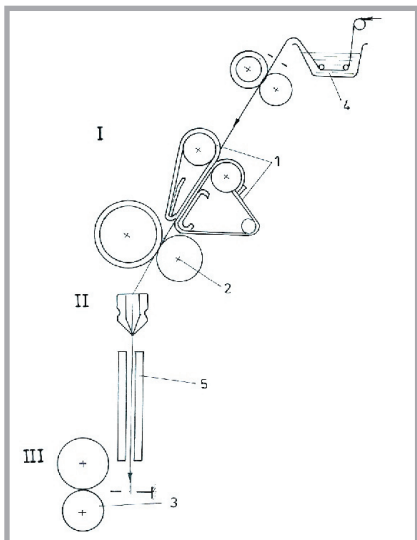


Figure 5. Principle of wet spinning with twister tube: I – drawing zone; II – twisting zone; III – winding system; 1 – wet tank; 2 – winding cylinder; 3 – twister tube; 4 – drying installation; 5 – conductor of the yarn; 6 – winding cylinder.

fabrics processed on weaving machines (looms) at a medium weaving speed.

Processing yarn into the woven fabrics is the test of the spinning system for the



Figure 6. Flax yarns wet spun with false twist.

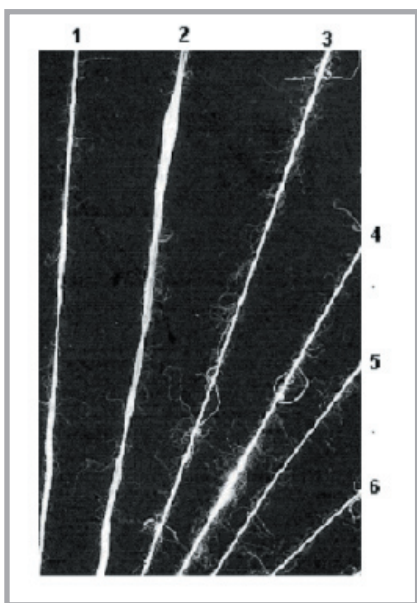


Figure 7. Flax yarns: 1, 2, 3, 4 – yarns with false twist of unretted flax; 5, 6 – yarns with real twist.

unretted flax yarn. Table 2 presents the average values of the characteristics of the new woven fabrics, as compared with those of the existing fabric Predana.

The unretted flax yarn Tt 86.2 tex used as weft for Predana fabric determined the following characteristics for the woven fabric (Table 2):

- strength on weft direction with 9.7% lower than that of the pre-made article, because the weft yarn of the testing article is almost 20% thicker;
- lower mass loss by friction, which means good stability of fibres in the yarn and a suitable behaviour of the woven fabric during its utilisation.

The friction resistance is comparatively higher than the pre-made fabric, which explains the stable joining of the structural elements. Mass loss is lower than that of the pre-made fabric's woven, which demonstrates a proportional increase in durability and, consequently, a source of economy.

Conclusions

Mathematical modelling and subsequent experimental verification permitted us to establish the optimum limits of the pressing forces exercised on all rollers from the crushing zones of flax stems processing for fibre extraction without retting. In this way, the recommended variation interval for these forces is between 4 and 8 daN, with the following distribution: 8-10 daN in the pre-crush zone, 8 daN in the first zone, 8 daN in the second, 6 daN in the third zone and 4 daN in the last crushing zone.

The maximum fineness of fibres delivered by the carding machine with the fibres length breaking proof for unretted flax is obtained for the following degrees:

- a carding degree between 87-108;
- a cleaning degree between 14-16.

The carding process should be progressive, to protect the fibre length. To this end we recommend working in the first carding group zone, at a carding degree ranging between 80-100 and a cleaning degree between 10-13.

With the new wet spinning system, we produced unretted flax yarn Tt 86.2 tex with a new structure, in which fibres are located parallel to the longitudinal axis.

Yarn strength is determined by the rally of the link substances after drying. The unretted flax yarn Tt 86.2 tex, used as weft for Predana fabric, has given the woven fabric a 9.7% lower strength on weft direction, in comparison with that of the existent fabric, because the weft of the pre-made fabric is almost 20% thicker. Mass loss by friction is lower than that of the pre-made fabric; which means good stability of fibres in the yarn and the suitable behaviour of the woven fabric during its utilisation.

Friction resistance is better in comparison with the pre-made fabric, which explains the stable joining of the structural elements. The mass loss lower than that of the woven fabric of the pre-made article shows the possibility of a proportional growth in the products' durability.

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