FILABILITY ANALYSIS OF WOOL FIBERS USED TO OBTAIN WORSTED WOOL YARNS

Lecturer, Ph.D., **Daniela NEGRU** [1], Assoc.prof., Ph.D., **Liliana BUHU** [1], MSc., Eng. **Ana-Cristina BĂRBIERU**[1]

[1] „Gheorghe Asachi" Technical University of Iași, Romania

REZUMAT. Prezenta lucrare abordează analiza filabilității pentru 13 variante de fir de lână pieptănată, cu finețea Nm 120. Variantele de fir analizate au în componență fibre de lână cu diferite fineți, respectiv lungime, fiind obținute pe mașini de filat cu inele cu filare compactă. Din această analiză se poate observa că finețea fibrelor este cel mai important factor de influență asupra filabilității. Odată cu creșterea diametrului fibrelor se poate observa o reducere a rezervei de filare.

Cuvinte cheie: fibre de lână, fire de lână pieptănată, filare compactă, filabilitate, rezervă de filare.

ABSTRACT. The present paper presents the analysis of the filability for 13 variants of worsted wool yarn, with the fineness of Nm 120. The analyzed variants consist of wool fibers of different fineness, respectively length, being obtained on ring spinning machines with compact spinning. From this analysis it can be seen that the fineness of the fibers is the most important factor influencing the filability. As the diameter of the fibers increases, a reduction of the spinning limit can be observed.

Keywords: wool fibers, worsted yarns, compact spinning, filability, spining limit.

1. INTRODUCTION

In the last two decades, the great innovation in ring spinning has been the introduction of compact spinning. Compact spinning has benefited from increased interest since its first presentation at ITMA '99 in Paris, capturing the interest of visitors. These machines have been installed in spinning machines all over the world. Why did the idea of getting compact wires come about? It is a question whose answer is very simple, namely: from the desire to obtain yarns of a higher quality than those made on the rings spinning machine. Compact spinning allows obtaining yarns with a much improved structure, which offers the following advantages:

• Low-hairness yarns used in textile materials with low pilling capacity. In addition, the lower hairness loss results in the benefits of preparing and obtaining products, including the possibility of removing sizing, creasing or waxing, thus resulting improved print quality;

• More resistant yarns that cause fewer breaks during spinning and subsequent processes;

• The possibility of using a lower torsion, and hence a higher production speed, to reach the "normal" resistance of the yarn;

• Yarns and textile materials with a nice touch and good drape.

Compact spinning, which has several advantages, is a modified classical spinning process that can be used in both short and long fibers.

From the point of view of the quality, appearance and use properties of textile products, the decisive elements are not only the type and the participation shares of blended fibres. The correct choice of component characteristics is essential (length, fineness, cross-sectional shape etc.).

Filability represents the ability of fibers to be transformed into yarns. This is assessed by filability limits, which are determined by the average number of fibers in the cross section of the yarn. Thus, the maximum average number in the cross-section of the yarn determines the lower limit of filability or minimum filability, and the minimum average number represents the upper limit of filability or maximum filability. In general, the bibliography indicates by filability the minimum number of fibers in the section of yarn obtained from the fibers of a blend, or the finest yarn that can be obtained from a blend. In order to be transformed into a yarn, a blend must meet the minimum filability requirement. The filability depends on the following characteristics of the fibers: fineness, length, resistance and elongation at break, elasticity and appearance.

The mean fibre length of the top affects the strength, appearance and surface characteristics of the yarn spun from it, and therefore the quality of the fabric and the garments made from the yarn.

2. MATERIALS AND METHODS

In this paper we analysed a number of 13 yarn variants with the fineness Nm 120 from wool fibers, which were obtained by compact spinning on the ring spinning machine with Zinser Modular Concept 451.

The 13 variants of worsted yarns Nm 120 made of wool fibers with different fineness analysed in this paper are presented in Table 1.

In the case of variants V1, V6 and V12 the yarns were made of fibers of the same diameter and of different mean lengths.

Table 1. **Fineness of fiber and yarn**

Yarn variant	Fibers diameter [μm]	The actual fineness of the simple yarn [Nm]
V1	13	119.4
V2	13.1	120
V3	14.5	122
V4	15.5	119.7
V5	15.5	120
V6	15.5	121.5
V7	16	120
V8	16	121.3
V9	16.1	120.7
V10	16.5	120.2
V11	16.5	120
V12	17.1	119.8
V13	18.4	119.4

The fibers filability is determined through the spinning limit (Slim), the diameter of the fibers and the length of the fibers.

$$S_{lim}=\frac{n_s\text{-}n_{smin}}{n_{smin}}\cdot 100 \qquad (2.1)$$

n_S is number of fibers in the cross-section of the yarn; n_{Smin} – minimum number of fibers in the cross-section of the yarn.

The minimum filability condition is determined by the minimum number of fibres in the cross section of the yarn (n_{smin}).

Filability is determined by the spinning limit, which is calculated by the average number of fibers in the cross-section of the yarn. Without taking into account other features, there is the principle: the finer the fiber, the higher the filability.

In order to be able to be converted into yarn, it is imperative that any blend meets the minimal filability condition.

In the processing of blends, it must be bore in mind that, at least in conventional ring spinning processes, fine fibers accumulate to a greater extent in the yarn core and coarser fibers periphery of the yarn.

3. RESULTS AND DISSCUTIONS

The fiber length and the length coefficient of variation were the basis for determining the filability coefficient, the values being presented in Table 2.

Table 2. **Filability coefficient in function of fiber length and length coefficient of variation**

Yarn variant	Fiber length [mm]			Fiber length coefficient of variation [%]			Mean		Filability coefficient
	HM_1	HM_2	HM_3	CV_{H1}	CV_{H2}	CV_{H3}	HM_m [mm]	CV_{Hm} [%]	
V1	60.6 57.3	57.7 57.9	58 57.6	45.4 48.8	48 47.8	48.5 49.4	58.18	47.98	0.9
V2	65.4	66.3	65.6	43.2	43.2	42.9	65.7	43.1	1
V3	60.4	63.5	61.1	48.2	44.7	42.8	61.6	45.23	0.96
V4	60.1	58.7	59	48.9	49.7	50	59.26	49.53	0.9
V5	62.6	64.2	63.4	48.3	45.3	46.8	63.4	46.8	0.96
V6	61.4 63.9 60.6 62	61.7 60 59 58.6	60.6 58.8 59.6 58.1	49.8 44.7 48.5 49.1	48 48 49.5 49.3	49.8 49.5 49.5 50.6	60.36	48.86	0.9
V7	65.5	63.8	63.2	45.1	45.8	46.5	64.16	45.8	0.96
V8	64.3	65.3	65.1	47.2	46.3	46.1	64.9	46.53	0.96
V9	63.5	60.7	65.8	41.9	43.5	43.2	63.3	42.86	1
V10	59.6	62.4	60.4	46.9	48.1	45.8	60.8	46.9	0.96
V11	68.6	68.4	69.1	43.6	42.9	41.1	68.7	42.53	1
V12	62.9 68.1	64.7 67.7	63.9 67.5	48.9 46.6	46.6 46.2	48.4 46.3	65.8	47.16	0.9
V13	71.2	70.1	71	48.8	41.2	40.5	70.77	40.2	1

The Hauteur (H) is the mean length of all lengths related to number of fibres in the wool sample. Yarn spinnability improves with increasing Hauteur, although beyond 80 mm, the improvement is only slight. The variation in the length is expressed as CV_H %.

Filability is also closely correlated with the Hauteur's length variation coefficient like so:

CV_H = 50% the filability coefficient is 0.90

CV_H = 45% the filability coefficient is 0.96

CV_H = 40 % the filability coefficient is 1

CV_H = 38 % the filability coefficient is 1.05

CV_H = 35 % the filability coefficient is 1.15.

For the calculation of the filability limit, the optimum number of fibers in the cross-section of the yarn was determined, a value that was taken in the calculation of the spinning limit (Table 3).

$$n_{so}=\frac{300}{\sqrt{Nm}}=\frac{300}{\sqrt{120}}=27.4 \text{ fibers} \qquad (3.1)$$

Table 3. **Spinning limit**

Yarn variant	Fibers fineness		Yarn fineness	Sectionl number of fibers	Spinning limit
	Diameter [µm]	Nm [m/g]	Nm [m/g]	n_s	R_F [%]
V1	13	5754	119,8	48	77,9
V2	13,1	5667	121,5	47	72,7
V3	14,5	4625	120,7	38	41,9
V4	15,5	4048	122	33	22,9
V5	15,5	4048	119,4	34	25,6
V6	15,5	4048	120	34	24,9
V7	16	3799	119,8	32	17,4
V8	16	3799	120,2	32	17,0
V9	16,1	3752	119,4	31	16,4
V10	16,5	3572	120	30	10,2
V11	16,5	3572	120,2	30	10,1
V12	17,1	3326	119,7	28	2,9
V13	18,4	2872	120	24	-11,4

5. CONCLUSIONS

From the analysis of the obtained spinning limit it can be observed that for the first three variants of yarn the spinning limit exceeds the recommended value of 30%, which determines a high cost of the yarn, due to the high cost of the raw material, but a very good behavior when processing on spinning.

With the increase of the diameter of the fibers it is possible to observe a decrease of the spinning limit, this reaching to values below 15% for fibers over 16.5 µm and even to negative values of the spinning limit to a diameter of 18.4 µm. These variants (V10 - V13) have led to a large number of breaks in the spinning machine and consequently to a lower productivity in spinning, a large number of defects and a lower quality of the yarn.

The optimal variants from the point of view of the spinning limit are V4 - V9, values corresponding to the diameter of the wool fibers between 15.5 and 16.1 µm. This was also confirmed by the behavior in fiber processing.

REFERENCES

[1] Lawrence, C.A., *Fundamentals of spun yarn technology*. Library of Congress Cataloging-in-Publication Data, ISBN 1-56676-821-7, 2002

[2] Lawrence, C. A.., *Advances in Yarn Spinning Technology*. Woodhead Publishing Limited, New Delhi, 2010

[3] Avram, D., Buhu, L., *Manualul Inginerului Textilist (Capitolul Filatura de lână)*. Vol. I. Editura AGIR, București 2002. ISBN 973-8466-10-5, 973-8466-11-3

[4] Buhu, L., *Teza de doctorat - Contribuții teoretice și experi-mentale la optimizarea procedeului de obținere a firelor compacte*. Iași, 2006

[5] Buhu, L., *Design industrial – fire*. Editura Performantica, ISBN 978-606-685-524-601-0, Iași, 2018

[6] Goktepe, F., Yilmaz, D., Goktepe, O., *A comparison of compact yarn properties produced on different systems.* Textile Research Journal, vol.76, nr.3/2006, 226-234

[7] Nicolic, M., Stjepanovic, Z., Lesjak, F., Stritof, A., *Compact spinning for improved quality of ring-spun yarns.* Fibres & Textiles in Eastern Europe, Vol. 11, No.4 (43), 2003, 30-35

About the authors

Lecturer eng., Ph. D. **Daniela NEGRU**
„Gheorghe Asachi” Tehcnical University of Iași, România

Graduate of "Gheorghe Asachi" Technical University of Iasi, Faculty of Textile, Leather and Industrial Management, specialization "Textile technologies" in 2007, Ph.D. since 2012, lecturer at the Faculty of Design Industrial and Business Management since 2014. Domains of competence: yarn structure, composite materials, conductive textiles.

Assoc. Prof. eng. Ph.D. **Liliana BUHU**
„Gheorghe Asachi” Tehcnical University of Iași, România

Graduate of "Gheorghe Asachi" Polytechnic Institute of Iasi, Faculty of Textile - Leather, specialization "Spinning - weaving" in 1992, Ph.D. since 2007, associate professor at the Faculty of Design Industrial and Business Management since 2019. Domains of competence: wool fibers processing, yarns structure and design, projects management, composite materials.

MSc., Eng. **Ana-Cristina BĂRBIERU**
Universitatea Tehnică „Gheorghe Asachi” din Iași, Iași, România

Graduate of "Gheorghe Asachi" Technical University of Iasi, Faculty of Textile, Leather and Industrial Management, specialization " Technology and Design of Textile Products" in 2012 and graduate of master's degree program „Quality Assurance in the Field ff Textiles and Leatherwork” in 2017.