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The Relationship between the Properties of Wool Mixtures and Their Spinning Ability.

M.Kulmetov, J.R.Mukhtarov, T.A.Toyirova, A.B.Zoirov.

Professor (Uzbekistan),Tashkent Institute of Textile and Light Industry
Researcher (Uzbekistan), Tashkent Institute of Textile and Light Industry
PhD (Uzbekistan), Tashkent Institute of Textile and Light Industry
Student (Uzbekistan), Tashkent Institute of Textile and Light Industry

ABSTRACT: The article presents an analysis of methods for designing the spinning ability of wool fibers on the basis of experiments of physical and mechanical properties of hybrid wool compared the design characteristics of the spinning ability of different wool fibers. According to the results of the calculation of statistical reserves of strength and actual tests of the yarn, appropriate recommendations are proposed.

KEY WORDS: wool, rational use of raw materials, the indicator of the level of product quality, the lowest linear density of yarn, reserve spinning ability

I.INTRODUCTION

Technological processes of wool spinning production are characterized by: multifactorial, complexity of the relationship and mutual influence between the quality of the products and the productivity of the equipment; significant instability of the feedstock for the main quality indicators.

It is known that the most important part of any technological system of yarn production is the area of mixture formation.

Preparation of the mixture begins at the design stage of the mixture with the desired properties in order to optimize the entire process.

Mathematical modeling allows to foresee and evaluate the results of various activities in advance and to choose the most effective ones [1].

The basis of the mathematical model of functioning of wool spinning production is the model of the production process of conversion of raw materials into finished products.

II.ANALYSIS OF EXISTING FILTERING MATERIALS AND RESEARCH RESULTS

The output flow function V(t) is a mathematical description (model) of the product flow, which includes the characteristics $X_1, X_2, \dots \dots, X_n$, , describing the properties of this product and determining the level of its quality. The quantitative indicator of the level of product quality Q is introduced by the functional

$$Q = T^n[v_0(t)] = \frac{t_2}{t_1}, \qquad (1)$$

where $t_2, t_1 -$ is the time interval in which the quality of products is estimated.

In the problem of product quality control, the indicator Q serves as a target function, and the problem itself is reduced to such a choice of control actions α, which delivers the maximum value of the indicator Q under restrictions imposed on the values of h, W and N, as well as fixed (given) properties of the initial flow $v_0(t)$.

When solving the issues of rational use of raw materials, the problem of reducing the cost of yarn while maintaining the required indicators of product quality and labor productivity is most often solved.

Complex indicators that take into account the composition of the fiber in the mixture, the spinning system, the level and condition of technology and production technology, is an indicator of the spinning ability of the mixture.

Consider some methods of calculating the spinning ability of wool mixtures.

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Method of A.A.Sinitsyn. The spinning ability of wool mixtures(mainly for the hardware spinning system) is determined by the formula (2).

$$A = \alpha_1 a_1 A_1 + \alpha_2 a_2 A_2 + \alpha_3 a_3 A_3 + \alpha_n a_n, \quad (2)$$

Where $\alpha_1, \alpha_2, \alpha_3$,..........α_n — fraction of components in the mixture; a_1, a_2, a_3 ,..........a_n — coefficients characterizing the change in the properties of the components when they are processed into yarn in the mixture. A_1, A_2, A_3,..........A_n — indicators of the spinning ability of individual components of the mixture.

For example, to determine the lowest calculated linear density of yarn T_c^0 from the mixture, the formula (1) is converted to the formula:

$$T_p^0 = \frac{1-\sum k_{back} \cdot \alpha_{back}}{\sum T_{com}^0 \cdot \alpha_{com}}, \quad (3)$$

where k_{back} — coefficient taking into account the lowering of the spinning ability of the blend by investing in her the return of waste; α_{back} — equity participation in a mixture of appropriate return waste production; T_{com}^0 — is the smallest linear density of the yarn in the development of only one component, put in the mixture, Tex; a_{com} - equity acusticamente. in a mixture.

M.V.Emmanuel [6] proposed to introduce into formula (3) a correction factor that takes into account the increase in spinning ability as a result of the introduction of new machines. For ring spinning machines, take this coefficient (H) equal to 1.2 and use the original formulas and data of **A.A.Sinitsyn**.

To account for possible variations in the spinning process, high volatility of raw materials on the basic indicators of quality, climatic conditions, plant etc.

M.V.Emmanuel introduced the concept of spinning reserve capacity (%) determined by the formula [2].

$$R = \frac{T_a - T_c^0}{T_c^0} 100, \quad (4)$$

where T_a — is the actual linear density of the yarn, tex; T_c^0 — is the smallest calculated linear density of the yarn, tex.

On the recommendations of M. Emmanuel spinning reserve capacity (%) must be in the range of $15 \leq R \leq 30$.

Based on the results of experimental studies, **V.A.Vorobyov** proposed to determine the spinning ability of wool mixtures by the value of the calculated linear density of the yarn produced from them [8]. The following formulas are proposed to determine the lowest calculated linear density of yarn [9]

For hardware system of spinning

$$T_c^0 = \frac{0{,}62t + (1-7{,}5t)\sigma}{\Pi(0{,}184 - 0{,}00092L)\sqrt{L}}; \quad (5)$$

where t— is the fineness (diameter) of the fiber, mm; σ— is the unevenness of the fiber on the fineness of wool, mm; Π— is the coefficient of spin; L — is the length of the fiber, mm.

Average values of the coefficients of spinners for different systems of spinning, a certain **V.A.Vorobyov**, on the basis of processing the experimental results, for the hardware to 0,330 0,348, and for thin-finned 0,80.

The actual linear density of the yarn is determined by taking into account the reserve spinning ability, which according to the recommendations of **V.A.Vorobyov** should be taken: for combed yarn R=30...40%, for hardware yarn R=30...56%.

The method of the least number of fibers in the cross section of yarn

It involves the determination of the calculated linear density of the yarn, depending on the number of fibers in its cross section.[1]

$$T_c^0 = d^2(1 + 0{,}0001 CV_d^2) n_{basic}/972, \quad (6)$$

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where d–is the average diameter of the fibers in the mixture, µm; CV_d - is the coefficient of variation in the diameter of the fibers in the mixture %; n_{basic} - is the minimum (basic) number of fibers in the cross section of the yarn, in which the spinning process occurs with normative breakage.

Similarly, the dependencies are obtained of formula **V.E.Gusev** [2]

$$T_c^0 = T_{mixture} n \quad (7)$$

where $T_{mixture}$ — is the linear density of the mixture fibers, tex; n — is the number of fibers in the cross section of the yarn.

It is theoretically established that the spinning process can occur in the presence of 22-24 fibers in the cross section of the yarn [1].

English scientist Martindale proposes to determine the minimum number of fibers in the cross section of worsted yarn, depending on the required quality of yarn. The quality of the yarn was estimated in percent indicator of the mean square roughness at a linear density (CV_N) [11]

$$CV_N = 112/\sqrt{n}, \quad (8)$$

where n — is the number of fibers in the cross section of the yarn.

If we take into account the unevenness of the fibers in the yarn by the diameter of the fibers in the mixture and the length of the fibers, the **Martindale** formula will take the form

$$CV_N = \frac{100\sqrt{1+0{,}004CV_d}}{\sqrt{n}}, \quad (9)$$

whereCV_d — mean-square roughness diameter, %.

It is established that the number of fibers in the cross section, pneumatic-mechanical spinning method – not less than 70-80, pure-wool hardware yarn ring spinning method of not less than 100, pneumatic-mechanical yarn spinning method of not less than 140 [1].

Currently, in engineering calculations, formula (5) is widely used in international practice, since it is based on parameters that are almost easily determined.

For Merino wool 70^q or 64^qcoefficient of variation in fiber diameter is about 23.6%. In the development of yarn from these types of wool basic linear density of yarn (tex) can be calculated by the formula

$$T = d^2 n_{basic}/917, \quad (10)$$

where d — is the average diameter of the fibers in the mixture, mcm;n_{basic} — the base number of fibers in the cross section of the yarn.

Method of V.K.Afanasyev – N.V. Lipchitz. The method assumes that the fibers in the cross section of the yarn are arranged in concentric circles by layers tightly adjacent to one another [12].

Knowing the linear density of the source fiber and choosing the value of the stratification of the yarn, you can determine the linear density of the yarn, which should be developed from this fiber, according to the formula

$$T_y = 3nT_f(1+n) + T_f, \quad (11)$$

where n— the number of layers of fibers in the cross section of the yarn; T_f — the linear density of the fiber, tex.

The disadvantage of the proposed formula is the difficulty of practical determination of the number of layers in the yarn, taking into account the influence of the real conditions of its production and the quality of raw materials.

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III. LITERATURE SURVEY

A method that takes into account the surface of the fiber. According to this method, the process of yarn formation is considered as the process of fiber compression during torsion. In this case, there are friction contacts between the fibers.

For the criterion of spinning ability of wool mixtures is proposed to take the area of contact between the fibers of the core of the yarn.

In [13] it is theoretically established that the area of contact between the fibers in the combed wool ring yarn is 50 mm^2. In the case of semi-combed wool spinning, the parallelism of the fibers in the yarn decreases and a large area of contact between the fibers (up to 100 mm^2) is required to ensure the necessary stability of the spinning, i.e. at the same length in the cross section of the yarn there should be a large number of fiber. In the case of hardware (pneumomechanical) spinning wool fiber parallelism in the yarn decreases sharply and in the core area of the yarn is 28 fibers. Then the smallest linear density of the yarn can be calculated by the following approximate formula

$$\mathrm{T}_y = 10\mathrm{T}_f + 8, \qquad (12)$$

where T_f – is the average linear density of the fiber, Tex.

When rewinding wool yarn to the rewinding frame with an electronic cleaner, the strength of wool yarns increased [14].

In engineering calculations with a sufficient degree of accuracy, the basic linear density of yarn (tex) can be determined by the formula used in international practice:

$$T_{basic} = \frac{d_{md}^2 (1+0{,}0001 CV_d^2) n_{basic}}{972} k_y k_l k_c \qquad (13)$$

where d_{md} – the average diameter of the fibers in the mixture, mcm; CV_d – the coefficient of variation for fiber diameter, %; n_{basic} – the base number of fibers in the cross section of yarn; k_y – coefficient taking into account the strength of the fibers; k_l – coefficient taking into account the length of the fibers; k_C – coefficient taking into account the condition of the wool fibers (normal, weed, burdock, etc.).

The dependence is based on the use of parameters that can be determined in the production environment. The influence of the length, strength and condition of the fibers in this calculation is taken into account by increasing the reserve spinning ability.

On the basis of calculations and experimental measurements the number of fibers in the cross section of the hardware yarn is taken to be 100, and pure worsted yarn – 40-45.

Reserve spinning ability yarn (%) is determined by the formula

$$R = (\mathrm{T}_a - T_{basic})/T_{basic} * 100 \qquad ,(14)$$

where T_a and T_{basic} – the actual and the underlying linear density of yarn, tex.

The calculation of the smallest linear density of yarns and other indicators of the spinning abilities of a heterogeneous mixture of wool determined experimentally in conditions of state of emergency “ТУРА СОБИР” and the laboratory of the Institute CENTEXUz on unprocessed and processed samples of variations of the local wool sheep breeds.

IV. EXPERIMENTAL RESULTS

The results of our experiments are presented, that the average fiber diameter 52,02 mcm, separated by coarse fiber 32,05 mcm, the proportion of thin fibers of 22.8%, semi-fine -20%, semi-coarse -42,8%, and the proportion of coarse fibers of 42.8%.According to the data after separation of the obtained semi-fine semi-coarse (1 variant) and semi-coarse - coarse (2) types of wool produced calculations for the spinning capacity and the spinning reserve capacity.

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For 1-variant nominal density 122.45 Tex, and for 2-variant 233.78 Tex. Reserve for 1-variant 42,86 %, for 2-variant 1,94 %.

According to the average values of fibers in the fleece calculate the stock option strands T_{basic} and T = 102 tex on the average density of the strands, taking N=100 for hardware strands and T=142 tex. (6) according to the formula

$$T_б = \frac{32{,}05^2(1+0{,}0001\cdot 908{,}4)\cdot 100}{972} = \frac{1027{,}2(1{,}09084)}{972} = 115{,}28 \text{ tex}$$

VI. CONCLUSION AND FUTURE WORK

Table 1.— The results of fiber testing and calculations based on the above methods are summarized.

Fiber length, l, mm	The linear density of the fibre, T_f, Tex	Fiber diameter d, mcm	Nominal linear density of yarn T, tex	The number of fiber in $n =$	The number of layers in the n_{bas}	Calculated the spinning indicators of ability of the mixture				
						By Gusev, T_c^0	By Martindale ,T	By V. K. Afanasyev-N. In.Lipitzu, T	As the surface b-n, T_y	By Vorobyov, T_c^0
60	1,5	39,5	102,9	8,28	2,07	9,42	8,23	30,1	18,5	
80	2,7	44	102,9	6,17	2,98	34,78	8,7	44	1,54	
80	2,7	44	142	7,25	1,81	19,55	3,5	4,39	28,7	
100	3,1	45,9	102,9	5,76	1.,41	17,36	3,03	35,78	28,1	
60	1,5	39,5	142	9,7	2,43	14,58	4,14	36,5	18,5	
100	3,1	45,9	142	6,77	1,69	20,99	3,56	45,38	38,1	
(Md)80 I v	**2,43**	**43,13**	**122,45**	**7,32**	**2,065**	**17,79**	**4,2**	**48,57**	**32,3**	**5,5**
120	2,9	53,2	300	10,3	2,58	29,87	7,3	53,26	28,9	
140	3,8	54	300	9	2,25	34,2	6,56	87,16	38,8	
140	3,8	54	142	6,4	1,53	23,01	4,41	47,93	32,8	
160	4,3	57,5	300	8,48	2,12	36,58	7,01	84,62	48,3	
160	3,1	45,9	102,9	5,76	1,44	17,8	7,03	35,78	33,2	
(Md)144 II v	**3,58**	**51,96**	**233,78**	**7,97**	**1,984**	**28,59**	**5,84**	**67,16**	**43,8**	**15,4**

$$CV = \frac{\sigma}{d}\cdot 100 = \frac{47{,}3}{57{,}07}\cdot 100 = 908{,}4$$

Reserve spinning ability by the formula (14)

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$$R_{\text{ф}1} = \frac{102 - 115{,}28}{115{,}28} \cdot 100 = 26{,}80\%$$

$$R_{\text{ф}2} = \frac{142 - 115{,}28}{115{,}28} \cdot 100 = 42\%$$

Estimated base line of separated local wool fiber

$$T_{\text{б}}^{0} = 52{,}05^{2}(1 + 0{,}0001 \cdot 908{,}4) \cdot \frac{100}{972} = 305{,}92$$

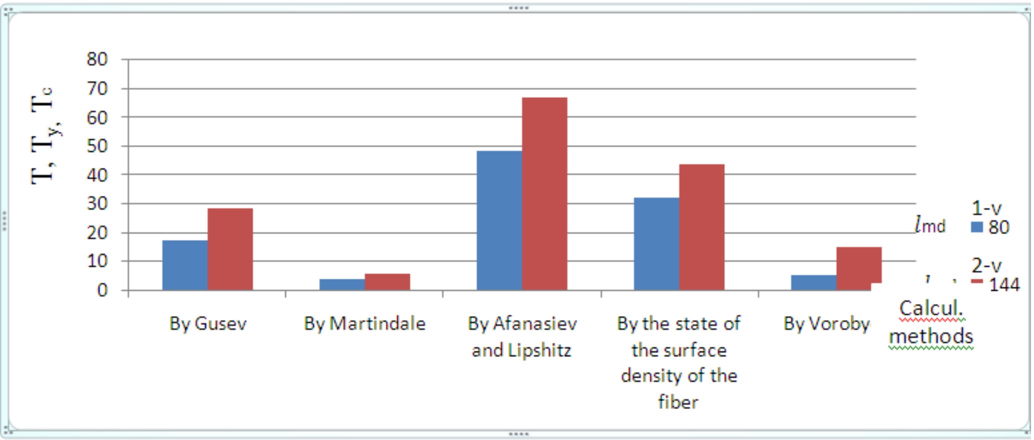
$T_{\text{н}}$=300 tex hardware wool yarn backup

$$R_{\text{ф}}^{0} = \frac{305{,}92 - 300}{109} \cdot 100 = 1{,}94\%$$

The basic linear density of wool yarn from fibers belonging to the thin, semi-thin, semi-coarse and coarse groups according to fineness in the composition of the local wool is $T_{\text{б}}^{0} = 305{,}92$ tex and the spinning reserve is aboutR_1=2 %; minimum linear density of yarn T=122,45 texreserve of spinning ability R_2=42,86 %.

According to the results for both mixtures, histograms of spinning ability are constructed depending on the methods of their calculations, which confirm our assumptions.

Figure 1. - Calculated the spinning ability of a mixture of fibers of wool



Thus, mixtures for the considered linear yarn densities can be used in the production of carpets, blankets, as weft yarn in carpet weaving, which will increase spinning ability and improve product quality.

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