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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

METHODS OF INVESTIGATION AND IMPROVEMENT OF THE WINDING STRUCTURE IN SPINNING BALLS OF COLORING PURPOSE

Specialty: 3326.01- Technology of materials and products of the textile and light industry

Field of science: Technical sciences

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Ganja-2025

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GENERAL DESCRIPTION OF THE RESEARCH

Relevance and degree of completion of the topic. Among the most processed consumer goods, a wide range of fabrics and fabric products are the most popular. Along with the physical and mechanical properties of these products, operational properties, especially color, are of great importance. In particular, the strength and wear resistance of fabrics used in clothing are as important as their pattern, the beauty of color, light resistance and resistance to washing.

Theoretical and experimental studies on dyeing in bobbins have shown that one of the important factors affecting the efficiency of this process and the quality of the yarn being dyed is the structure of the bobbin winding[1]. It is characterized by the structure of the winding, its specific density, the angle of intersection of the windings, the order of the turns in the winding, the size and shape of the winding.

The most important of these parameters from the point of view of the dyeing process are the specific weight of the winding, its weight and the size of the bobbin. In this regard, the study of thread shaping, structural parameters and the determination and application of the most appropriate values of these parameters is one of the important issues. These problems are to some extent reflected in the solid rolls and rolls used in the textile and weaving industries. However, the issues related to the study of the structure of bandages prepared for dyeing, in particular, the structure of the roller or navoi, and improving their quality, are not sufficiently covered. It has recently been found that the cartridge in which the yarn is wound has a significant impact on the dyeing process and the quality of the dyed yarn[2]. Research in this area has focused on new high-performance dye cartridges and their testing. However, the effect of the cartridge design on the defects that occur during dyeing and the amount of yarn crumbs obtained has not been studied.

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[1] Крашение пряжи в поковках / В.Ф. Андросов, В.Ф. Александров, М.И. Артым, В.Б. Кленов, Р.П. Якимчук . -Москва: Изд. ЛИ, - 1974, -225 с.15
[2] Fettahov, R. ve diğ. Terbiye ve Boyama Amaçlı Patronlar Üzerine Bir Araştırma // -Türkiye: “Tekstil Maraton” Dergisi,- 2005,- s. 45-51

Purpose and objectives of the study. Goals and objectives of the study. The aim of the study is to study the main design parameters of winding in flushes and to develop optimal values to increase the efficiency of the yarn dyeing process and improve the quality of dyed yarn.

In accordance with the set goal, the following tasks were defined:

- theoretical study of the structural parameters of bobbins prepared for dyeing;
- theoretical study of the structure of the warping roller used for dyeing;
- experimental study of the structural parameters of bobbins prepared for dyeing;
- experimental study of the effect of the structure of the dyeing cartridge on the dyeing of yarn;
- determination of the effect of the cartridge structure on the quality of dyeing and the amount of yarn scraps;
- verification of the results of the experiment in production conditions and preparation of recommendations.

Research methods. The theoretical basis of the research is fundamental theoretical and experimental research, patent materials, laws of physics and higher mathematics on the formation and structure of yarns for yarn dyeing. The experiments were carried out by measuring the structural parameters of transverse skeins obtained from cotton yarn on a rewinding machine, and the yarn color values after they were dyed with appropriate devices and tools. The figures obtained as a result of the experiment were developed on the basis of Excel and mathematical statistics methods.

Main provisions to be submitted for defense:

- methods of dyeing threads in skeins and factors influencing this;
- theoretical and empirical models determining the design parameters of coils;
- methodology for theoretical determination of the structural parameters of the warping roller and the obtained equations;
- method of attaching yarns to the warping roller or beam;
- the effect of the coefficient of the useful surface of the coloring cartridge on the quality of coloring;

-the effect of the coefficient of the useful surface of the dye cartridge on the amount of yarn crumbs;

- verification of experimental results in production conditions and preparation of recommendations.

Scientific novelty of the research a new theoretical method for studying the structure of the winding in cross-wound bobbins was developed, the concept of a full winding layer in cross-wound bobbins and a method for theoretical determination of the parameters of this layer were proposed. It was determined that the process of winding formation in bundles such as warp rolls and beams formed from many yarns occurs in a regular and irregular stepwise manner, and a theoretical study of the structural parameters of the winding was carried out for the general arrangement of yarns in the warp roll. In this case, the concept of layers in parallel winding was improved and theoretical formulas of practical importance for determining the parameters of the winding layer were obtained. A method for attaching yarns to a winding roll or bobbin was proposed and an Azerbaijani patent was obtained for this; An experiment was conducted to determine the effect of the specific density and weight of the winding on dyeing in the bobbin, and a functional relationship was obtained between these parameters and the color difference value of the yarn. The influence of the cartridge structure on the quality of the dyed yarn and yarn residues obtained after dyeing was investigated, and recommendations were made for improving the quality of dyeing and reducing yarn residues.

Theoretical and practical significance of the study. With the application of the proposed theoretical method for determining the design parameters of the skeins, washings of the type of bobbin, roller and navoi are obtained, which increase the efficiency of the dyeing process and the quality of coloring of the dyed yarn. The application of the obtained empirical equations determines the most favorable values of the structural parameters important for staining. Thanks to the use of the proposed new method, the amount of yarn separated into scraps at the bottom of the beam is reduced by 3-4 times. It has been proven through the production experiment that as a result of the application of the new plastic dyeing cartridge recommended in this work, the color difference value of the dyed yarn decreases by 42-56%, thereby increasing its quality. At the same time, due to the reduction of dyeing defects formed at the bottom of the cartridge after dyeing with the application of this cartridge, the amount of scrap obtained is reduced by 70-80% compared to the amount of scrap obtained with existing cartridges.

Approbation and application of works. The main provisions and results of the dissertation were published in the 2nd International Conference on Innovations in the Textile Industry (March 18-19, 2013) COVTEX 2013, Faislabad, Pakistan, the 6th International Conference "The Future of Textiles" (Bucharest, October 17-18, 2013), 3. International Symposium on Fiber and Polymer Research (March 8-9, 2018, Bursa, Turkey), 2nd International Ten Awareness Conference (December 13-15, 2018, Canakkale, Turkey), Ist -International Congress on Modern Sciences Tashkent Chemical-Technological Institute May 10-11, 2022 Tashkent, Internatıonal Scıentıfic Conference Parıs. France 20-21.06.2023, Prospects for the development of the Food and Textile Industry in our Republic and challenges for the future" III Republican Scientific and Practical Conference, (May 21, 2019, Baku), Scientific and methodological seminars of the department of Technological Machines and Industrial Equipment of the Azerbaijan State University of Economics (2016-2020) a report at an expanded meeting of the department of Engineering and Applied Sciences of the Azerbaijan State University of Economics (May 17, 2024, Baku).

New cartridges with a high surface area coefficient (0.81) were tested at Gilan Textile Park LLC and it was found that the amount of yarn crumbs formed during dyeing is reduced by 70-80%, depending on the type of yarn. the difference decreases by 0.27-56%. In Gilan Textile Park, the production parameters of ready-to-paint rolls and a high-performance cylindrical plastic dye cartridge were tested and a recommendation act for its use was signed..

The name of the organization where the dissertation work is performed. The dissertation was performed at the Department of Engineering and Applied Sciences of the Azerbaijan State University of Economics..

The total volume of the dissertation with an indication of the volume of the structural sections of the dissertation separately. The dissertation consists of an introduction, five chapters, conclusions, a list of used literature in 158 counts and an appendix. There are 48 figures, 16 tables and 3 appendix. In the content of the dissertation, the introduction was 6 pages from 10649 characters, the first chapter was 32 pages from 60448 signs, the second chapter was 18 pages from 24383 characters, the third chapter was 41 pages from 60811 characters, the fourth chapter was 16 pages from 22486 signs, the fifth chapter was 35 pages from 57753 signs, the results were 3 pages from 6021 characters, recommendations to production were 1 page from 1140 characters and the list of used 158 consists was 16 pages from 26465 signs. The volume of the dissertation consists of 170 pages of computer writing, the total volume is 243691 characters (excluding the list of used literature and 243641 characters).

CONTENT OF THE WORK

İn the introduction substantiates the relevance of the topic, determines the purpose of the research and the issues to be solved, indicates the scientific novelty of the work, its practical significance, and explains the research methods.

First chapter. Information from modern scientific and technical sources, patent materials and existing technical documents (catalogs of machinery and equipment, standard materials, etc.) published in our country and the world were studied and analyzed. According to these materials, a brief explanation of the methods of staining fibers and threads is given, the factors affecting the staining are indicated. It is determined that bobbin dyeing is the most common method among other methods due to its high productivity, low production and the possibility of dyeing any yarn [12].The design parameters of their winding have a great influence on the coloring of threads on bobbins and rollers. The most important of them are the specific weight of the skein, its weight, the state of the threads in the skein, the density distribution in the skein, the size of the bobbin.

B.F. Androsov, S.A. Alexandrov, I.I. Weiner, P.N. Kiselyov and others made a significant contribution to scientific achievements in the field of yarn dyeing, especially the process of roll dyeing. Minakov

A.P., Gordeev V.A.[3], Proshkov A.P. in the study of the design parameters of winding into a bobbin, roller or navoy and in improving their quality. Yu.D.Efremovun[4], M.N. Nurievin[5]. Theoretical and practical studies of V.P. Zaitsev play a special role.

As a result of the analysis of literary sources, the following conclusion was made. One of the important measures that must be taken to improve the efficiency of the dyeing process and further improve the quality of the yarn produced is to improve the quality of the yarn so that it meets the requirements of dyeing. The method of determining the winding layers formed by turns in the bobbin, the number of turns located in these layers, the distance between the turns and the length of the thread in the layers is not sufficiently developed. Significant theoretical and practical results were obtained in the study of the formation and structure of washouts such as roller and navoi. However, in these studies, the study of such washes prepared for staining has not been studied enough. Therefore, it is important to study the formation and structure of these flushes.

Second chapter it is devoted to a theoretical study of the structure of the coils prepared for dyeing. Here, the process of forming a cross coil is analyzed and the parameters characterizing its structure are examined [1]. In particular, structural issues such as formation of layers in crosswinding and the location of yarn coils in the coil have been thoroughly investigated.

The formation of the filled winding layer is explained in Figure 1. During one reciprocating movement of the thread guide, the intersecting turns of thread 1 and 2 form an elementary winding layer on the cylindrical cartridge with equal pitches h1, h2 and h3 (Figure 1.*a*)

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[3] Гордеев, В.А., Волков, П.В. Ткачество. / В.А. Гордеев, П.В. Волков, -Москва: Изд. ЛИ, - 1974, -620 с.

[4] Ефремов, Е.Д. Основы теории наматывания нити на паковку // - Москва: Легкая и пищевая проышленность. -1982, № 3, - с.16-20

[5] Nuriyev M. N. Toxucu bağlamalarının strukturuna və xassələrinə nəzarət metodlarının və vasitələrinin işlənməsi / Texnika elmləri doktoru elmi dərəcəsə almaq üçün doktorluq dissertasiyası /- Bakı, 2010, 335 s.

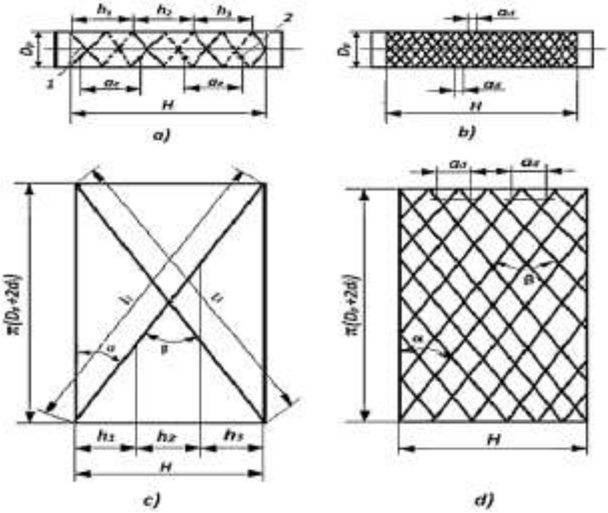

Figure 1. Winding layers formed at the beginning of cross winding:

a) - elementary layer, b) - full layer, c) - disclosure of the elementary layer, d) - disclosure of the full layer.

After that, the second elementary layer is wrapped between the first layer of the coils and reduces the gap between the coils. After the second elemental layer, the third, fourth and subsequent elemental layers are wrapped and form a filling layer (fig. 1b). As can be seen from the figure, the thickness of the full layer at the intersection points is equal to two times the diameter of the thread, and the diameter of the thread in non-intersecting places. In other words, the height of the full layer varies between the diameter of the thread di and its 2*di*, which is twice the size, depending on the position of the crossbars and the area of the cavity. For this reason, the thickness of the full layer of filling for cross winding is assumed to be 1,5 *di* with a small error [8].

In this chapter, the parameters of the winding layer, the length of the thread in the winding layer at the arbitrary diameter of the coil, and other structural parameters are theoretically determined. For this, for the first time, a method for determining the basic parameters according to the length of the yarn in the coil and the size of the winding has been developed. Based on this method, theoretical Dus-tours were obtained that determine such parameters as the number of winding layers in the coil, the number of coils in one layer, the distance between the coils and the density of the coils [6].

Number of winding layers in coil:

$$m_q = (D - D_0) / 2\delta \tag{1}$$

The number of total passes, i.e. the total winding cycle of the yarn traveller for winding the yarn length *L* into the coil:

$$M = L / l_t \tag{2}$$

Number of turning points of coils in a layer of arbitrary diameter D_x coil:

$$\kappa_x = 10^5 \pi D_x \delta \rho \, Sin \alpha / 2T \tag{3}$$

The length of the yarn in a thick layer of an arbitrary diameter of the bobbin;

$$L_q = 10^5 \pi D_x \delta \rho \, l_t \, Sin \alpha / (2T) \tag{4}$$

The distance between adjacent *a* windings in the full layer;

$$a = 2T / (10^5 \delta \rho \, Cos \alpha) \tag{5}$$

Total number of curls in a full layer:

$$n_{dq} = 10^5 l_t \delta \rho \, Sin\beta / (4T) \tag{6}$$

One of the important structural parameters of the rolls prepared for coloring is the number of intersection points in the layer and their location. Therefore, a formula was obtained to determine the number of points of intersection of the windings in the full layer.

$$n_{kn} = 0{,}5 \, n_{dq} = 10^5 l_t \delta \rho \, Sin\beta / (8T) \tag{7}$$

Fill factor of the fill layer

$$K_d = 10^3 \pi C^2 \rho / 4 = 785 C^2 \rho \ , \tag{8}$$

where m_g-is the number of thick layers in the bobbin, the outer diameter of the *D*- is the outside diameter of the bandage, cm; D_0 -is the inner diameter of the bandage, cm; δ is the thickness of the full yellow layer, cm; ρ -special yellowing density g/cm^3; Arbitrary diameter D_x - is the winding cm; α - the angle of lifting of the yarn winding in the winding; T-is the linear density of yarn, Tex; l_{t}- is the length of the thread wrapped in a coil in a loop, cm; the distance between the threads in a is the full layer cm; n_{dq} - is the total number of folds in the full layer, and β -is the angle of intersection of the folds.

According to these formulas, it is possible to determine the most suitable winding parameters that improve the dyeing process and the quality of the dyed yarn.

İn the third chapter deals with the theoretical study of the structure of the roller and examines the features of its formation. To date, the structure of the winding roller has been studied for cases I and II of the arrangement of the yarn spools in the winding[6]. Therefore, the results obtained can only be used for these two cases. The general arrangement of the thread turns for case III has been studied in theoretical studies[7] [8]. The position of the yarn turns on the roller is shown in Figure 2.

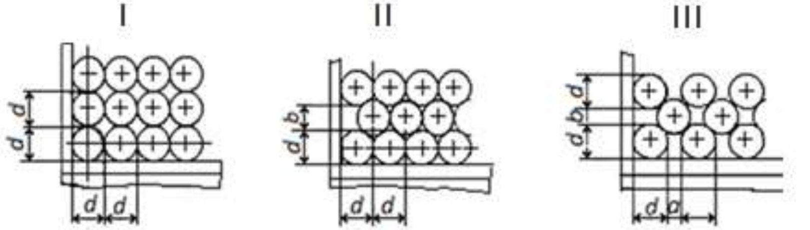

Figure 2. The arrangement of the thread turns in parallel winding

As a result of our theoretical research, it was determined that during the formation of the winding roller, two winding stages of the winding threads occur, irregular and regular [4]. It was determined that the

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[6] Зайцев, В.П. Исследование структуры намотки и процесса формирования партионных сновальных валиков: / Диссертация кандидата технических. наук. / -Ленинград, 1971, 180 с.

[7] Fettahov, R., Durur, G., Palamutçu, S. Toxuculug maşınlarında alınan sarınmaların quruluşunun tədqiqi // Материалы докладов II Международной научно-технической конференции. Проблемы Машиностроения XX1 Века, -Баку: - 2001, - s.

[8] Fatdakhov, R.M., Jangirova, M.H. Strukture and Formation of Parallel Winding, // “Fıbros Materials XX1 Century. İnternational Comference and Exibition, - St. Petersburg, -2005, -p.1-7.

irregular winding of the winding threads occurs in the lower part of the roller, and therefore the surface of the winding here takes on a wavy shape. As a result, a tension difference occurs between individual threads during unwinding and breakage increases. In the rollers used for dyeing, color differences occur in the threads located in these parts. All this leads to an increase in the amount of scrap coming out of the rollers in subsequent processes.

In order to eliminate this defect, a method of attaching the yarns to the bobbin or roller has been developed [23]. According to this method, first an intermediate element, i.e. an adhesive layer, is formed at the end of the warp threads, and then this layer is glued to the roller body, connecting the warp threads to the roller. This method is explained as follows according to Figure 3:

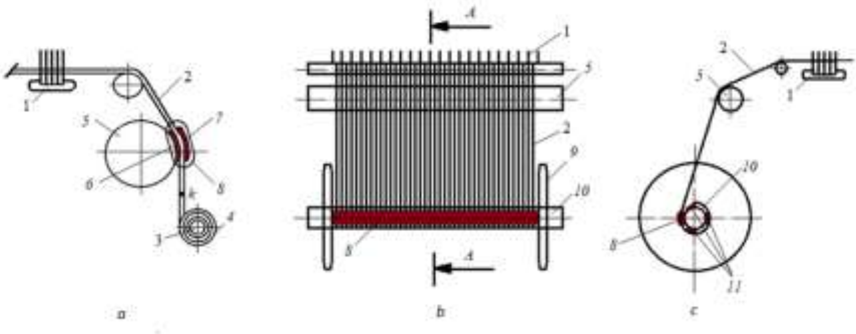

Figure 3. Scheme of obtaining an adhesive layer and gluing it to the roller.

a-Scheme of obtaining the layer, b-front view of the gluing, c-side view of the gluing.

The adhesive layer is obtained as follows; The warp threads (2) passed between the teeth of the separating comb (1) of the warp winding or sizing machine are wound 3-4 times on a rod (3) to form a bundle (4). Then, a double-sided adhesive tape (6) with a width of not less than 50 mm is glued along the length onto the output shaft (5) of the machine. After that, the warp threads are pulled towards the output shaft by holding both ends of the rod (3) and glued to the adhesive tape (6) on the surface of the shaft. Then, tape (7) is glued to the surface of the warp threads symmetrically to the tape (6), forming an intermediate element – a connecting layer (8) (Figure 3a).

The resulting intermediate element is pulled with the help of a rod (3) and glued to the body (10) of the beam (9) (Figure 3b). Then the warp threads are cut at its end along the line k and the rod is removed. After that, the machine is started and the winding process begins. To ensure that the threads are firmly attached to the navoi body, several double-sided adhesive tapes (11) with a width of 50 mm are glued along its entire length in the radial direction (Figure 2c). An Azerbaijani patent (I 2023 0007) has been obtained for the proposed method.

Theoretical studies have determined that the yarn turns in the warp beam are in the III position under regular winding conditions. Therefore, the structural parameters of the rollers prepared for dyeing are determined for this condition. The structural parameters of the dyeing rollers include the density of the original winding layer, the thickness of the layer, the value of the distances a and b between the turns, the filling factor of the winding and the length of the yarn wound on the roller. Theoretically, these parameters were determined in [5].

To date, the study of the main design parameters of the spinning roller has been carried out mainly for the first and second position of the yarn turns (fig.2a,2b). However, the threads are in the third position (fig. 2c).

In the third position of the coils, such important parameters as winding, the density of the winding layer, the magnitude of the distances a and b between the coils, the winding fill factor and the length of the winding thread are theoretically determined [5]. For this purpose, the process of formation of a filled layer of threads on a roller was clarified and a formula was obtained for determining the density of this layer, which has the following form.

$$P_d = M_d/H = \frac{4 \cdot 10^2 MLd}{\pi H(D^2 - {D_0}^2)} \quad (9)$$

where P_d-is the density of the thick yellow layer, round/cm; M_d is the number of threads in the full layer of the roller, H -is the width of the winding on the roller (the distance between the edges of the roller), cm; M -is the number of threads wound on the roller; L- is the length of the thread wound on the roller, m; the diameter of the d_i-thread, cm, the outer diameter of the D-coil, cm, D_0-the diameter of the housing roller, sm.

A thick layer is meant as a wrapping layer. A full layer is considered to be a yellowing element formed by a number of continuously twisted strands. The solid layer can be divided into two types: horizontal and vertical. The thickness (height) of the winding layer is determined by the diameter of the yarn. The height of the layer is equal to or less than the diameter of the thread, depending on the location and position of the strands. In the first position, the horizontal and vertical thick layers are wrapped in a single layer formed by loops located in the horizontal and vertical planes. In this case, the thickness of the layers is equal to the diameter of the thread. In the second position, the windings are located side by side in the horizontal layer and at a distance b from each other in the vertical layer. In this case, the vertical axis of the coils wrapped around the 1st horizontal layer lies on a vertical perpendicular line passing through the point of contact of two adjacent substructures. Therefore, the lower points of the upper circles are not on the upper surface of the lower rings, but on a vertical line passing through their line of contact. Consequently, the thickness of the horizontal layer will be less than the diameter of the thread. In the second case, the thickness of the vertical layer is less than the diameter of the thread. In the third position, the thickness of the winding layers in both directions is less than the diameter of the thread. For this reason, in the second and third positions of the coils, the winding layer is formed from a certain part of the coils arranged in two rows[17]. The thickness of the winding layers for the III general position of the windings in the winding can be determined by the following simple formulas:

$$h_{ü} = 0{,}5\sqrt{4d^2 - (d+a)^2} \quad (10)$$

$$h_{ş} = 0{,}5\sqrt{4d^2 - (d+b)^2} \quad (11)$$

The value of the distance a of the horizontal winding layer P_d, calculated by the formula (9), is determined by the following equation for the density of the filled layer:

$$a = 1/P_d - d \quad (12)$$

The value of the distance b in the layer can be calculated using the following formula:

$$b = \sqrt{4d^2 - (d + a)^2} - d \quad (13)$$

The distances a and b in the winding vary depending on the position of the windings. In this study, a theoretical formula was obtained for determining the filling factor of the full layer of the winding roll.

$$K_d = 10^5 \pi d^2 \rho /4T \quad (14)$$

Thus, using equations (9)-(13), the structure of the warp rollers to be produced for dyeing can be designed.

Forth chapter An experimental study of the structure of rolls prepared for staining was carried out. Linear density 25. The experiment was carried out on soft cylindrical skeins wound with different tension on cotton yarn Tex card [9]. The thread tension was measured using a SCHMIDT DTMX-200 digital electronic device. The device is connected to a computer and can display the voltage value in both numbers and diagrams. The value of the winding stiffness was measured with an HP 5 device with a Shoremeter stiffness. Based on the values obtained as a result of the experiment, the functional relationship between the tension and stiffness of the thread and the specific winding is expressed by the following empirical formulas:

$$\rho = -0{,}0001F^2 + 0{,}0106\, F + 0{,}3414 \quad (15)$$

$$\rho = -0{,}0007S^2 + 0{,}1125S - 3{,}756, \quad (16)$$

where ρ - specific weight of the package, g/sm^3; F- yarn tension, kN

S - rigidity of the wrapper, kN/m.

Empirical formulas are defined using Excel. The accuracy of the shots was determined by the value of the R^2 coefficient shown by this program. Its value is 0.99994 for formula (9) and 0.9997 for formula (10). As can be seen from these figures, the accuracy of the formulas is very high. To study the relationship between the linear density of yarn and the specific density and stiffness of the bobbin, an experiment was conducted for card threads with a density of 8.33 Tex, 16.4 Tex, 25 Tex, 29.6 Tex, 36.9 Tex and 60 Tex.

Based on the obtained values, an Excel program and diagrams showing the relationship between them were built, and the following empirical equations of dependence were obtained..

$$S = 6{,}6.10^{-4}\, T^2 - 0{,}92T + 88{,}11 \quad (17)$$

$$\rho = 2.10^{-5}\, T^2 – 0{,}0033\ T + 0{,}5709 \qquad (18)$$

The values of the parameter R^2, indicating the degree of accuracy of the equations, were 0.9978 for equation (16) and 0.9998 for equation (17). As can be seen from these formulas, the specific density and stif-fness of the winding vary parabolic depending on the linear density of the yarn. However, the curvature of the parabola is so small that it can be considered as a rectilinear dependence. In this chapter, experiments were carried out on yarns of 16.4 Tex and 36.6 Tex to change the specific weight of the winding by the diameter and height of the bobbin.

Empirical expressions of the dependence of the stiffness and specific gravity of the winding on the height of the coil are obtained.

Linear density 16.4 for Tex yarn

$$S = 0{,}3834H^2 - 5{,}6639\ H + 86{,}90 \qquad (18)$$

$$\rho = 0{,}0024\ H^2 - 0{,}0356\ H + 0{,}61 \qquad (19)$$

Linear density 36.6 for Tex yarn

$$S = 0{,}4721H^2 - 5{,}0507\ H + 79{,}12 \qquad (20)$$

$$\rho = 0{,}0024\ H^2 - 0{,}0362\ H + 0{,}56 \qquad (21)$$

The value of the coefficients of determination R^2, showing the proximity of the values calculated by these formulas to the experimental ones, is in the range of 0.968-0.976.

Experiments show that the change in the specific gravity and stif-fness of the coil depending on the height of the coil is the same as in a solid coil. The value of its rigidity and specific gravity at the edges of the winding is about 1.3-1.5 times higher than in the middle regions.

Fifth cchapter factors affecting yarn dyeing in bobbins; An ex-periment was conducted to determine the effect of the specific gravity and weight of the winding, the design of the dye cartridge and the coef-ficient of the useful surface of the cartridge on the dye. In the experiment, cotton yarn with a linear density of 41.6 Tex was used. The dyeing process was carried out on a two-bobbin dyeing machine. In this figure, the dependence graphs between the specific density of the winding and the color difference values of the yarn are shown.

The results of the experiment conducted to study the effect of the specific density of the winding on the color of the dyed yarn are given in Figure 4. In this figure, the dependence graphs between the specific density of the winding and the color difference values of the yarn are shown. In the curves in that graph, point 1 represents the low value of the specific density of the winding, point 2 represents the average value, and point 3 represents the high value.

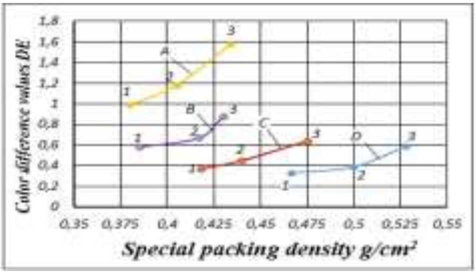

Figure. 4. Graphs of changes in the average values of the color difference in films of different densities:

A -is a coil with a diameter of 18 cm, B is a coil with a diameter of 15 cm, C- is a coil with a diameter of 12 cm, D- is a coil with a diameter of 9.0 cm.

As can be seen from figure 4, the change in the average DE value in all coils depends on the specific winding density. With increasing density, the average value of ΔE also increases. However, the rate of change in growth depends on the weight of the coil. In heavier coils, the increase in the average value of ΔE is higher. That is, under the same dyeing conditions, the growth rate of the color size in a label with a diameter of 18 is twice as high as in a skein with a diameter of 9 cm.

Graphs of the functional relationship between the weight of the bobbin and the values of the yarn color difference are shown in Fig.5.

As can be seen from Figure 5, the pattern of the change in the value of the color difference of the yarn ΔE depending on the weight of the bobbins is the same regardless of the value of the specific density of the winding. With increasing bobbin weight, the value of ΔE increases in the form of a polynomial curve. From this figure, it is once again clear that in bobbins with a low specific gravity (curve 3) the ΔE values are smaller than in bobbins with a high density (curves 2 and 3).

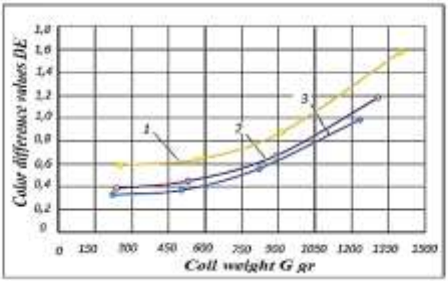

Figure. 5. Graphs of the dependence of the weight of the bobbin on the average value of the color dimension[9]:
1 - at the upper value of the specific gravity; 2 - at the average value of the specific gravity; 3 - at the lower value of the specific gravity.

In order to determine the effect of the cartridge's useful surface area coefficient (FSC) on dyeing, dyeing experiments were conducted on 4 types of plastic cartridges with a linear density of 25 Tex cotton yarn and FSC of 0.390; 0.421; 0.443; 0.587; and 0.813 [15]. Based on the obtained values, dependence diagrams between the color difference value and the useful surface area coefficient were obtained. This diagram, shown in Figure 6, was constructed using the EXSEL program.

As can be seen from Figure 6, the color difference value of the yarn decreases with the increase in the useful surface coefficient. Thus, the color difference value DEort had the largest value in bobbins on a cartridge with a FSE of 0.39, and the smallest value was in bobbins wound on a disc cartridge with a FSE of 0.813.. A 2-fold increase in the useful surface coefficient of the cartridge leads to a 2.5-fold decrease in the average color difference value. This also indicates that the quality of dyeing in bobbins on disc cartridges with a high useful surface coefficient also improves by 2.5 times.

As can be seen in figure 5, the color diffe-rence ΔE decreases rapidly when the Fsa changes from 0.39 to 0.443, the color difference ΔE decreases rapidly when the Fsa changes from 0.39 to 0.443. After that, the decline occurs at a slow pace, and when the Fsa reaches 0.81, ΔE takes the value of 0.312. and when Fsa reaches 0.81, ΔE takes the value 0.312.pace, and when Fsa reaches 0.81,ΔE ta-kes the value 0.312. pace, and when Fsa reaches 0.81, ΔE takes the value 0.312. pace, and when

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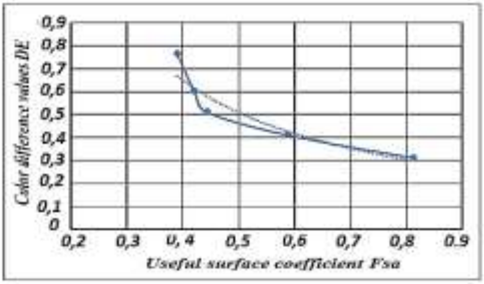

Figure 6. Graph of the relationship between the value of thecolor difference and the coefficient of the useful surface.

Taking this regression equation as a function of $Y = ax^b$, we get it an empirical formula in Excel:

$$\Delta E = 0{,}2382\ F_{S\text{ə}}^{-1{,}094} \tag{23}$$

The biggest disadvantage of dyeing threads in bobbins is the formation of weakly colored spots in the form of dots or lines on the lower layers of the winding, i.e. on loops in layers that come into contact with the surface of the bobbins and very close to it. The coefficient of the useful surface is 0.49 to determine the effect of the coefficient of the useful surface of the cartridge on the number of crumbs; 0.58; 4 plastic cartridges 0.79 and 0.81 were obtained. Each cassette is wrapped with cotton yarn with a linear density of 25 Tex, 25x2 Tex and 60 Tex..

A yarn analysis device was used to calculate defects. After that, the defects are cut out, removed from the board and weighed on an accurate scale. The percentage of crumbs is calculated for each yarn depending on the weight of the resulting crumbs and the total amount of yarn in the bobbins. Experience has shown that in skeins wound on all cartridges, the amount of crumb decreases in all 3 threads as the useful area of the cartridge increases. At the same time, this decrease is more noticeable in the twisted yarn. The graphical dependence of the amount of crumbs on the coefficient of the useful surface of the cartridge is shown in figure 7.

From the figure it can be seen that the cartridge with a useful surface area of 0.81 has a low percentage of crumbs and is almost equal to each other.

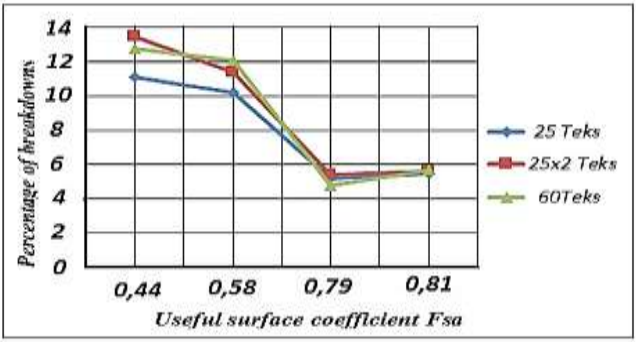

Figure 7. Diagram of change of scrap percentage depending on useful surface coefficient of cartridge [13].

In this experiment, along with determining the number of errors, the size of defects was also investigated. During the experiment, it was found that in the coils of existing cartridges with a small useful surface, almost all defects on the yarn had the form of lines and a length of 3-6 mm. Therefore, the percentage of crumbs in the yarn in these reels was very high, as can be seen from the table. This defect mainly manifests itself in the form of dots and lines longer than 3 mm in yarn dyed in new cartridges with a large useful surface. In addition, the number of these defects is more than twice the number of defects that occur in yarn wound on existing cartridges. This proves that one of the ways to improve the quality of yarn dyed in bobbin dye and reduce the amount of yarn crumbs in the process is to use dye cartridges with a high useful surface for rolls prepared for coloring.

This chapter calculates the expected economic effects from using the method of tying threads to the beam, as well as from using a dye cartridge with a high coefficient of useful surface. It was found that the expected annual economic effect per weaving machine as a result of using the proposed method is 826 manat, and the annual economic effect for the enterprise GILTEX LLC, which has 154 weaving machines, is 139,467 manat. As a result of using a dye cartridge with a high coefficient of useful surface, the expected annual economic effect per ton of dyed yarn is 905.6 manat, and for GILTEX LLC with a daily production of 700 kg of yarn is 150,321.1 manat. The expected annual economic effect for the Giltex company as a result of the implementation of the dissertation is 289,788 manat.

Results

1. The concept of a filled winding layer for cross winding is proposed, and formulas for determining the parameters that determine its formation are proposed. An analytical method for determining the structural parameters of winding on a bobbin is proposed. Based on this method, it is possible to determine such parameters as the number of winding layers in a bobbin, the length of the yarn and the number of turns in a layer, the distance between the turns.

2. As a result of experiments conducted to study changes in rigidity and specific density of winding depending on yarn tension, its linear density, bobbin diameter and height, the following was established:

- winding rigidity increases linearly depending on the winding speed and yarn tension. The specific density of the winding also increases with increasing yarn tension, but this increase occurs along a quadratic curve and at a slow speed;

- With an increase in the diameter of the spool, the value of rigidity and specific density in the layers and in the total winding gradually decreases. It was found that the values of hardness and specific density obtained during unwinding are higher than those obtained during winding.

- With an increase in the diameter of the bobbin, the value of rigidity and specific density in the layers and in the total winding gradually decreases. It was found that the values of hardness and specific density obtained during unwinding are higher than those obtained during winding.

3. Based on theoretical studies of the formation of a roller according to the location of the turns, the factors affecting its structure and shape have been determined. The number and wavelength of waves formed on the surface of the winding depend on the number of wound

yarns, the linear density of the yarn, the type and width of the roller. As the winding density increases, the number of waves increases, and the wavelength decreases.

4. The essence of the winding layer in the roller has been clarified, and practically important formulas have been obtained that allow determining the density and height (thickness) of the winding layer. A method for determining the structural parameters of a parallel winding obtained from multiple yarns has been developed. Analytical formulas have been proposed to determine the actual density of turns in the winding layer, the distances between turns in radial and horizontal winding layers, the filling factor of the winding, and the length of yarn wound on the roller.

5. In order to improve the quality of the winding at the bottom of the beam and reduce the amount of scraps, a method of fastening the threads to the bobbin was proposed and an Azerbaijani patent was obtained. The application of this method allows to reduce the amount of yarn scraps remaining at the bottom of the beam during the weaving process by 2-3 times.

6. One of the main factors affecting the quality of dyeing on a bobbin is the structure of the bobbin winding and the weight of the yarn on the bobbin. As a result of experimental studies on the dyeing of cotton yarns with active dyes, the following were determined:

- with an increase in the specific density of the winding on bobbins, the value of the color difference E in the yarn increases. However, this increase occurs in different ways depending on the weight of the bobbin. Thus, in light-weight bobbins with a very high specific density, the value of the color difference of the yarn is much lower than in heavy-weight bobbins with a low specific density;

- in light bobbins with a diameter of 9 cm to 15 cm, the increase in E occurs at a low speed, and in bobbins with a diameter of 15 cm to 18 cm (weight 1300-1500 g) at a higher speed.

- under normal dyeing conditions and parameters, it is not recommended to use cylindrical bobbins with a diameter of more than 15 cm and a specific density of more than 0.38 g/cm3. However, if such bobbins are used, it should be carried out by determining the optimal values of the pressure, temperature, dyeing time and other dyeing parameters of the dyeing solution.

- an increase in the useful surface coefficient of the cartridge leads to a decrease in the number of dyeing defects formed in the lower layers of the dyed bobbin and the size of the defects. Thus, an increase in FSE from 0.49 to 0.81 allows you to reduce the amount of chips formed at the bottom of the bobbin by 70-80%.

7. The economic efficiency of the method of connecting the waft threads to the beam and applying the dyeing cartridge with a high useful surface coefficient was calculated. It was determined that the expected annual economic benefit for the GILTEX LLC textile factory is 289788 AZN.

Recommendations for manufacturing

1. In order to achieve high quality of dyeing during the dyeing process, it is recommended to use cylindrical rolls with a diameter of 15 cm and a specific density of 0.38-0.40 g/cm^3 under normal mode and parameters of dyeing. However, if it is necessary to use coils of a larger diameter, then dyeing should be carried out by determining the optimal values of pressure, temperature and other parameters of dyeing the coloring solution.

2. It is recommended to use high-performance plastic or elastic dye cartridges with a useful surface coefficient from 0.70 to 0.81 to achieve high quality coloring and reduce the amount of crumbs of dyed yarn.

3. To improve the quality of winding in the lower part of the roller and reduce the amount of defects, it is recommended to use the proposed method of tying the warp threads to the beam.

4. It is considered appropriate to include the proposed analytical methodology for determining the structural parameters of the bobbin and warpng roller in the textbooks of students studying textile engineering.

The main content of the dissertation is published in the following scientific papers:

1. Mahmudova, N.R., Farzaliyev, M.H. An Experımental Study On The Structure of Dyeıng Bobbıns //2nd International Conference on Value

Additıon and Innovation in Textiles (18-19 March 2013) COVTEX 2013, Pakistan, Faisladabad,-2013. – p.268-275.

2. Mahmudova, N.R., Fettahov, R. Levent oluşumunun incelenmesi // Textile Technologies. -cilt 7,- 2013. No1.-s.33-39.

3. Mahmudova, N.R. Study on the wındıng structure of beam. //6th Internatıonal Conference, The Future of Textiles, Bucharest, - October 17-18. - 2013. – p.28-35

4. Mahmudov, N.R., Farzaliyev M. H. the Graphic-analytical study of the structure of the beam, resulting in a joint winding machines //- Baku: Theoretical and applied mechanics, in 2014. No. 3-4. - p. 97-101.

5. Mahmudov, N.R., Farzaliyev M. H. determination of parameters of the arithmetic structure // - Baku: Theoretical and applied mechanics, - 2015. No. 1.- pp. 98-102.

6. Mahmudov N.R., Farzaliyev M. G. Theoretical study of the build settings bobbin cross // Izvestiya vuzov. Textile production technology, - 2015. № 6 (360). - pp.83-88.

7. Fettahov, R., Yeşil, Y., Mahmudova, N.R. Dokuma üretiminde kullanılan sargı çeşitleri // Bartın Üniversitesi Türkiyə Mühendislik ve Teknoloji Bilimiler Dergisi.- cilt 3,-2015. Sayı 1.- s.33-36.

8. Makhmudova, N.R., Farzaliev, M.G. Theoretical parameters of the structure of the cross-winding bobbin // Eurasian Union of Scientists (ISU). - M., -2015. №12(21). - pp.80-83.

9. Makhmudova, N.R., Farzaliev, M.H. Experimental study of the effect of specific gravity and weight of the wrapper on the dye // - Baku: Theoretical and Applied Mechanics, -2016. №3-4.- pp.44-52.

10. Mahmudova, N.R. Paralel sarğılı sarım yapılarında iplik uzunluğunun teorik hesaplanması // Bartın Üniversitesi Mühendıslık ve Teknoloji Bilimler Dergisi. - cilt 6, - 2018. Sayı 1.- s.1-5.

11. Mahmudova, N.R., Farzaliyev, M.H. Kompozit materıalların üretiminde kullanılan sargı yapısının ıncelenmesi // 3.Uluslararasi lif ve polimer araştırmaları sempozyumu, - Bursa: -2018. -s.108-109.

12. Makhmudova, N.R. Yarn dyeing methods and factors influencing it //- Baku: Scientific Works of IGEU, -2018. No.1. - pp.123-128.

13.Mahmudova, NR. Bobin boyama kalitesinin iyileştirşlmesi ve iplik telefleriinin azaltılması üzerine bir araştırma//2nd International

Conference On Awareness, Bildirler kitabı, -13-15 Aralıq 2018.- s.437-444.

14. Mahmudova, N.R. Pamuk ipliğinin boyanma kalitesine bobin ağırlığının ve sarım yoğunluğunun etkisi // X. Uluslararası arge proje pazarı international randd brokerage event. - Mart 2018,- s.247-248.

15. Mahmudova, N.R. A Study on improving the quality of the bobbin dyeing and reducing yarn waste. // Journal of Awareness. – cilt 3,- 2018. Sayı: özel.- p.777-786.

16. Farzaliyev, M. H. Makhmudov, N.R. The influence of linear density of yarn on the stiffness and density of winding the bobbins // proceedings of the III Republican scientific-practical conference "prospects of development of the food and textile industries in our country and the challenges ahead", and Baku - 2019. - pp. 123-126.

17. Mahmudov, N.R. The method of calculation of parameters of the parallel winding of the intrinsic design // Izvestiya vuzov. Technologies. textile industry. - 2019, № 4 (382). - Pp. 88-93.

18. Makhmudova, N.R. Types of cartridges used in yarn dyeing // Materials of the Republican scientific and practical conference "Prospects for the development of the food and textile industry in the republic and tasks for the future",- Baku: - 2020. - pp.86-89.

19. Makhmudova, N.R. Influence of cartridge design on yarn dyeing on bobbins // Izvestiya vuzov. Technologies. The Texas language industry. - 2020, №5 (389).- pp.69-73.

20.Nigâr Makhmudova (2022). Experimental method for determining the deformation of warp threads on looms. Eastern-European Journal of Enterprise Technologies, 1 (1 (115)), p. 76–85

21. Nigar Mahmudova (2022). Formatıon and Structure of Packages Manufactured Wıth Multı -therad Wındunq. I[st] International Congress on Modern Sciences, May 10-11, 2022. p.p1181-1188.Tashkent

22. Nigâr Makhmudova (2023) Analysis and Reduction Methods of Yarn Waste Formation in Weaving. V Internatıonal Scıentıfic Conference Parıs. France 20-21.06.2023. p. 56-61

23. Mahmudova N. Əriş saplarının navoya bağlanması üsulu. Azərbaycan patenti, I 2023 007, 2023

The defense of the dissertation will be held on "**19**" "***september*** 2025", at **10^{00}** at the meeting of the one-time Dissertation council BFD 4.30 of under the Azerbaijan State Agrarian University.

Adress: Az 2000, Azerbaijan Republic, Ganja city, 450, Ataturk avenue.

Dissertation is accessible at the Azerbaijan State Agrarian University library.

Electronic versions of the dissertation and its abstract are avaialable on the official website of the Azerbaijan State Agrarian University

Abstract was sent to the required addresses on « **24** » ***june*** 2025.

Signed for printing: 20.06.2025
Paper format: (210x297) 1\4
Volume: characters: 39558
Number of hard copies: 30