World Bulletin Publishing
Online Publishing Hub

World Bulletin of Education and Learning (WBEL)

ISSN (E): 3072-175X | Volume 2, Issue 9, September 2026

https://worldbulletin.org/index.php/1

A MATHEMATICAL MODEL FOR EVALUATING QUALITY INDICATORS OF NOVEL-STRUCTURE KNITTED FABRICS

Sadoqat Umarjonovna Rakhmatova
Associate Professor of the Department of Design, PhD
Namangan State Technical University Textile Engineering
sadoqat.ziynat@gmail.com
Tel: (+99894) 905 52 28.

Abstract:
This study focuses on the mathematical modeling of the physical, mechanical, and technological properties of knitted fabrics. The research combines theoretical analysis with experimental investigations to evaluate and improve the quality characteristics of the produced knitted materials. The proposed mathematical approach makes it possible to establish relationships between the structural and technological parameters of knitted fabrics and their resulting quality indicators. In particular, the study considers the breaking load and reversible deformation of knitted fabrics and examines the possibility of predicting these characteristics in advance during the production process. The adequacy of the developed mathematical models is evaluated using appropriate statistical methods, including Fisher's criterion and regression coefficients. The obtained results demonstrate the potential of mathematical modeling as an effective tool for predicting fabric performance, improving product quality, and optimizing technological parameters. The application of the proposed approach can also contribute to more efficient production processes and provide a scientific basis for achieving greater economic efficiency in knitted fabric manufacturing.

Keywords: Textile engineering and technology, mathematical modeling, theoretical research, experimental research, theoretical-experimental approach, knitted fabric, stitch density, ring pitch, breaking load, reversible deformation, quality indicators, model adequacy, Fisher's criterion, regression coefficients, prediction, technological optimization.

World Bulletin of Education and Learning (WBEL)
ISSN (E): 3072-175X
Volume 2, Issue 9, September 2026

https://worldbulletin.org/index.php/1

Introduction

The importance of research work in the development of all sectors of the national economy of Uzbekistan is increasing, and production enterprises are being improved based on the achievements of world science. This improvement is carried out through its automation and mechanization, and the application of new machinery and technology [1; 5-10b].

Methodology & empirical analysis

Depending on the methods of implementation, research work is divided into the following types: theoretical, experimental, and theoretical-experimental.

Theoretical research is analyzed based on a known pattern, and the relationship between the parameters of a technological process or object is studied theoretically, while experimental research is carried out through experiments.

Currently, the introduction of new machinery and modern computer technologies into the production process requires a thorough and high-quality conduct of scientific research.

In theoretical-experimental R&D, both theoretical and experimental results are taken into account, and theoretical-experimental research is currently being used more frequently.

Technological processes in the textile industry consist of a complex of physical and chemical phenomena, which can only be successfully investigated using modern achievements in science and technology. Therefore, it is advisable to conduct scientific research based on mathematical modeling.

It is advisable to effectively use multi-factor mathematical modeling when studying the input parameters that determine the structure of knitted fabrics.

II. Results

The input factors x1 - ring pitch A (mm), x2 - ring row height V (mm), x3 - horizontal density, and Rg are taken as the influencing factors.

Y1 – breaking load R (N) along the length and width, and Y2 – reversible deformation εo (%) along the length and width were selected as output factors.

World Bulletin Publishing
Online Publishing Hub

World Bulletin of Education and Learning (WBEL)

ISSN (E): 3072-175X | Volume 2, Issue 9, September 2026

https://worldbulletin.org/index.php/1

When studying the influence of knitted fabric production on the structure of the fabric, the following variation levels and intervals of factors were selected (Table 3.1).

Table 3.1. Selection of levels and intervals of change for the factors under study

Factor names and labels	Transformation levels			Transformation interval
	-1	0	+1	
x1 - ring pitch, A mm	0,39	0,405	0,42	0,015
x2 - ring row height, V mm;	0,43	0,445	0,46	0,015
x3-horizontal density, Rg (pcs.)	120	122	124	2

To determine the significance of the regression coefficients, Student's t-test and Fisher's criterion were used to verify the adequacy or inadequacy of the mathematical model.

In the study, the main task set before mathematical modeling was to determine the breaking load and reversible deformation of the knitted fabric using factors affecting the knitted fabric, and to obtain slope diagrams of the isoline based on computational models using programs written in the Pascal programming language. Based on the factors affecting the knitted fabric, we can determine the indicators of breaking load and reversible deformation through these isolines.

The TOT results showed that the process under study is represented by a higher-order equation. Therefore, to obtain a second-order regression mathematical model, a central non-composite experiment (CNCE) was selected and implemented, which is simpler and more convenient than other methods and is widely used in the study of technological processes in the textile industry. Based on the experimental results, we are looking for a second-order regression multivariate mathematical model. As a result of this experiment, the following general regression model can be obtained:

$$Y_R = b_0 + \sum_{i=1}^{M} b_i x_i + \sum_{\substack{i=j=1 \\ j\neq 1}}^{n} b_{ij} x_i x_j + \sum_{i=1}^{M} b_{ii} x_i^2 \quad (1)$$

World Bulletin Publishing
Online Publishing Hub

World Bulletin of Education and Learning (WBEL)

ISSN (E): 3072-175X | Volume 2, Issue 9, September 2026

https://worldbulletin.org/index.php/1

Or, since three factors are involved in our experiment, the expression above takes the following form:

$$Y_R = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_{12}x_1x_2 + b_{13}x_1x_3 + b_{23}x_2x_3 + b_{11}x_1^2 + b_{22}x_2^2 + b_{33}x_3^2 \quad (2)$$

In the equation

b_0...b_1... are regression coefficients,

x_1, x_2, x_3 - coded values of factors.

Using the standard working matrix of the central non-composite experiment, the regression coefficients of the second-degree regression mathematical model were determined; as a result of the process of verifying their significance and recognizing the adequacy of the index, the following was obtained.

Central non-composite experiment

№	Factors			x_1x_2	x_1x_3	x_2x_3	x_1^2	x_2^2	x_3^2	Y_1(in length and width)		Y_2(in length and width)		$S_u^2(Y_1)$		$S_u^2(Y_2)$	
	x_1	x_2	x_3														
1	+	+	0	+	0	0	+	+	0	702	236	92	94	11	7,8	1	1,25
2	+	-	0	-	0	0	+	+	0	420	216	93	96	12	8,2	1,13	0,9
3	-	+	0	-	0	0	+	+	0	303	94	76	82	14	10,1	1,2	1,14
4	-	-	0	+	0	0	+	+	0	478	147	93	96	15	8,2	1,9	1,4
5	+	0	+	0	+	0	+	0	+	732	258	82	94	16	8	1,04	1,8
6	+	0	-	0	-	0	+	0	+	742	228	82	94	11	6,7	1,03	1,2
7	-	0	+	0	-	0	+	0	+	300	96	76	96	9	9,5	1,12	1,5
8	-	0	-	0	+	0	+	0	+	416	112	85	96	12	11,4	1,5	1,5
9	0	+	+	0	0	+	0	+	+	478	174	85	96	13	9,4	1,76	1,8
10	0	+	-	0	0	-	0	+	+	475	170	75	95	8	9,1	1,21	1,5
11	0	-	+	0	0	-	0	+	+	474	164	82	90	7	7	1,8	1,34
12	0	-	-	0	0	+	0	+	+	480	152	84	96	14	11,5	1,6	1,4
13	0	0	0	0	0	0	0	0	0	475	138	85	96	13	7,2	1,5	1,2
14	0	0	0	0	0	0	0	0	0	478	174	88	93	14	10,2	1,3	1,9
15	0	0	0	0	0	0	0	0	0	450	182	86	84	11	10,7	1,4	2

The matrix must use (+), (-) and 0 values

World Bulletin Publishing
Online Publishing Hub

World Bulletin of Education and Learning (WBEL)

ISSN (E): 3072-175X | Volume 2, Issue 9, September 2026

https://worldbulletin.org/index.php/1

Трикотажнинг узиш кучи (Y1-эни бўйича)ни оптималлаштириш бўйича регрессион моделлар:
Below, using Table 3.2, the regression coefficients of the second-degree regression mathematical model investigating the breaking load of knitted fabric along the Y1 width were determined, and in the same order as above, we obtained a regression mathematical model in the final form:
Taking into account the identified regression coefficients, the equation is written:

$$Y_R = 164{,}7 + 61{,}1x_1 - 0{,}4x_2 + 3{,}75x_3 + 18{,}25x_1x_2 + 11{,}5x_1x_3 - 2x_2x_3 + 7{,}4x_1^2 + 3{,}2x_2^2 + 3{,}3x_3^2$$

It is known that if the calculated value of the criterion is less than the table value, that coefficient is not significant and is excluded from the equation. The studies revealed that the coefficients b_2, b_23, b_22, and b_33 are insignificant for the parameters under study:

The equation is rewritten with significant coefficients:

$$Y_R = 164{,}7 + 61{,}1x_1 + 3{,}75x_3 + 18{,}25x_1x_2 + 11{,}5x_1x_3 + 7{,}4x_1^2$$

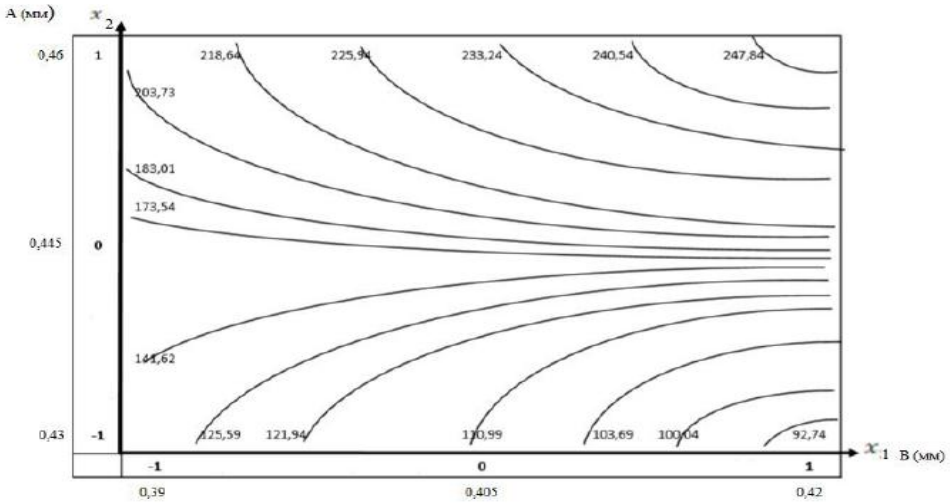
When the input parameter changes from the accepted minimum (-1) value of the first (x_1) and second (x_2) factors to the maximum (1) value, the smallest and largest values of the breaking load (Y1) (along the width) are described using the average value of x_3=0. At values in the range of 0.405÷0.42 x1-ring pitch A (mm), the height of the ring row V (mm) reaches 92.74, i.e., the smallest values of the breaking load (YR) in the range of 0.43÷0.445, and at values in the range of 0.405÷0.42 x1-ring pitch A (mm), the height of the ring row V (mm) reaches 247.84, i.e., the highest values of the breaking load (YR) in the range of 0.445÷0.46 (Fig. 1a).

World Bulletin Publishing
Online Publishing Hub

World Bulletin of Education and Learning (WBEL)

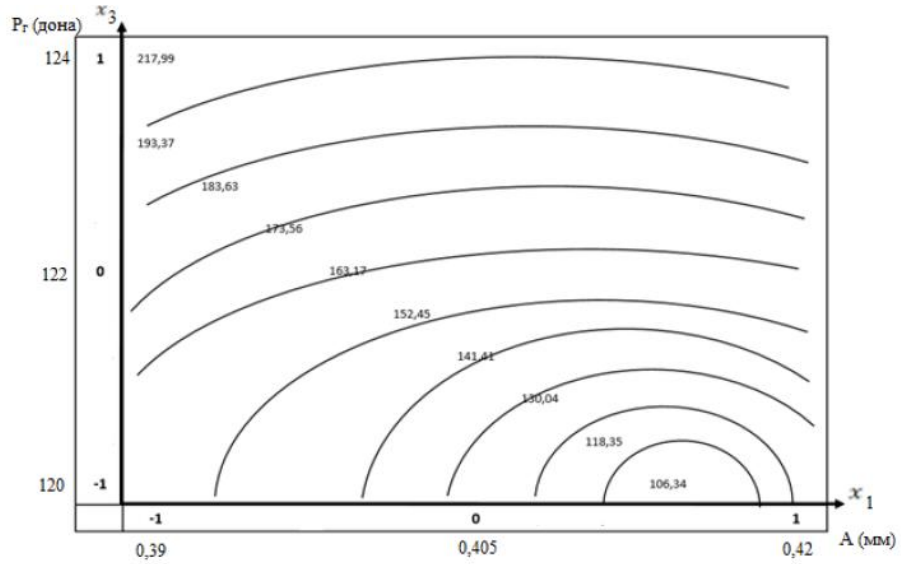
ISSN (E): 3072-175X | Volume 2, Issue 9, September 2026

https://worldbulletin.org/index.php/1



1a-figure. $x_3=0$

The graph above shows the values for achieving the lowest and highest values of the breaking load. When the accepted values of the factors (x_1) and (x_3) change from (-1) to 1, the breaking load (Y1) (widthwise) was determined using the average value at x_2 = 0. Using the diagram, the lowest values of the breaking load (YR) are achieved at values of x1 ring pitch A (mm) within 0.405–0.42, with a horizontal density Pg (piece) of x3 within 120–122, i.e., 106.34, and at values of x1 ring pitch A (mm) within 0.39–0.405, with a horizontal density Pg (piece) of x3 within 122–124, reaching 217.99, i.e., the highest values of the breaking load (YR) (Fig. 2, b).



2 б-figure. x2=0

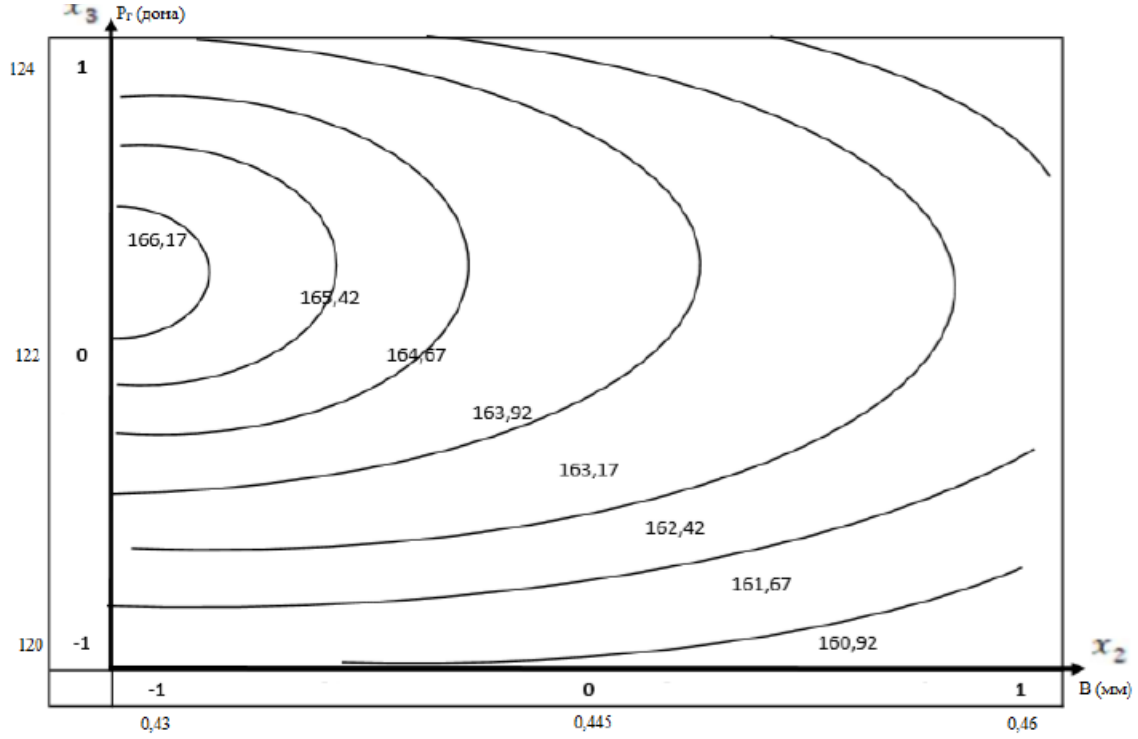
World Bulletin Publishing
Online Publishing Hub

World Bulletin of Education and Learning (WBEL)

ISSN (E): 3072-175X | Volume 2, Issue 9, September 2026

https://worldbulletin.org/index.php/1

This graph shows the values of achieving the minimum and maximum values of the breaking load (along the width) using the average value of the accepted values of the factors x1=0, (x2), and (x2), as they change from (-1) to 1. In the diagram, the lowest values of the breaking load (YR) are achieved when the knitted fabric's x2-ring height B (mm) is within the range of 0.445–0.46, while the horizontal density Pg (piece) is within the range of 120–122, i.e., 160.92, and the highest values of the breaking load (YR) are reached (166.17) when the knitted fabric's x3-ring height B (mm) is within the range of 0.43–0.445 and the horizontal density Pg (piece) is within the range of 122–124 (Fig. 3, c).



3.15 c-figure. x1=0

Conclusions. According to the results of the study, summarizing the three cases, the highest values of the breaking load (Y1) are achieved when the loop pitch (x1) is A (mm) 0, and (x2) when the loop height of the knitted fabric is B (mm) 0, and the third factor (x3) is 1.

$$Y_R = 164{,}7 + 61{,}1 * 0 + 3{,}75 * 1 + 18{,}25 * 0 * 0 + 11{,}5 * 0 * 1 + 7{,}4 * 0 = 168{,}45$$

World Bulletin Publishing
Online Publishing Hub

World Bulletin of Education and Learning (WBEL)

ISSN (E): 3072-175X | Volume 2, Issue 9, September 2026

https://worldbulletin.org/index.php/1

Consequently, the obtained regression mathematical model represents the studied process with sufficient accuracy.

Based on the analysis of regression equations, the dependencies of the influence of the knitting on technological and physical-mechanical indicators of the change in the density of the fabric along the loop step, the height of the loop row and the horizontal were determined.

Through a central non-compositional experiment, a regression equation was obtained between the breaking load and reversible deformation properties of double-layer knitted fabrics, and taking into account the results of its analysis, the rational structure and parameters of the knitted fabric were determined, ensuring high consumer properties.

REFERENCES

1. U.X.Meliboyev. To`qimachilik sanoati texnologik jarayonlarini modellashtirish asoslari. Namangan. “Adabiyot uchqunlari”, 2020. -216 (5-10 bet)
2. https://hozir.org/iqtisodiy-samaradorlikning-mohiyati-va-mezoni.html
3. Rahmatova Sadoqat Umarjonovna, Dadamirzayeva Shaxlo Maxamadali qizi; Salayeva Nozima Sattarovna. “Trikotajning qaytar deformatsiya (Y2-bo‘yi bo‘yicha)ni optimallashtirish bo‘yicha regression modellar. Dastur. № DGU 21141. 27.12.2022 y
4. Rahmatova Sadoqat Umarjonovna. “Mahalliy xomashyolardan samarali foydalanish hisobiga olingan yangi trikotaj to`qimlarini tadqiqi orqali mahsulot assortimentini kengaytirish” mavzusida texnika fanlari nomzodi(PhD) dissertatsiya ishi. Namangan 2022y. 113-115b.
5. Rahmatova Sadoqat Umarjonovna., Kholikov Kurbanali Madaminovich. Study of effects of changes on knitted tissue structures on physical-mechanical performance. ЭКОНОМИКА. СОЦИОЛОГИЯ. ПРАВО Материалы II международной научно-практической конференции (31 марта 2021) Астрахань, 20-22-бет
6. Rahmatova Sadoqat Umarjonovna, Tursunkulova Maxsuda Suyarkulovna1, a), Mamatova Xadicha Kurbanali qizi2, b), Shahlo Mahamadali qizi2, d), Kurbanali Kholikov Madaminovich. Basic Theory Of Air Permeability Of

World Bulletin Publishing
Online Publishing Hub

World Bulletin of Education and Learning (WBEL)

ISSN (E): 3072-175X | Volume 2, Issue 9, September 2026

https://worldbulletin.org/index.php/1

Knitted Fabric Selected On The Basis Of Mathematical Model. PLITIWISC-2022 International conference AIP Conference Proceedings 2789, 040010 (2023) https://doi.org/10.1063/5.0145851 RESEARCH ARTICLE | JUNE 23 2023 pages 040010-1 - 040010-8

7. Rahmatova Sadokat Umarjonovna, Shogofurov Shaxboz Shokirjon o'g'li, Kholikov Kurbanali Madaminovich. Study the effects of changes on knitted fabrics structures on physical-mechanical performance. Scientific and technical journal of NamIET ISSN 2181-8622 VOL 6 – Issue (1) 2021 42-49бет nammti_ilmiy@bk.ru
8. ГОСТ 28882. «Полотна трикотажные для верхних изделий. Нормы остаточной деформации». М.: Стандартинформ, 2009.
9. Rahmatova Sadoqat Umarjonovna, Xoliqov Kurbanali Madaminovich. Study of physical and mechanical properties of knitted fabrics in the new structure. // - Novateur publications international journal of innovations in engineering research and technology [IJIERT], VOL 8, Issue 10, Oct. -2021 y. p.130-136.
10. Rakhmatova Sadoqat Umarjonovna, Oxunov Rustamjon Nematovich, Obidova Irodaxon Nozimjonovna, Kholikov Kurbanali Madaminovich. Study of the effect of changes in the composition of raw materials on the technological performance of knitted fabrics in the new structure. // - Scientific and technical journal of NamIET, VOL 3, – Issue (1), 2021 y., 65-73 p. (05.00.00; №33).
11. С.У.Рахматова, Қ.М.Холиқов. Янги таркибли трикотаж тўқимасини технологик кўрсаткичлари тадқиқоти. O`zbekiston Respublikasi Oliy va o`rta maxsus ta`lim vazirlik miqyosidagi ilmiy-amaliy onlayn konferensiya materiallari. // - «Ilm-fan va texnikaning rivojlanishida innovatsion yondashuvlar» 2020 yil 20-noyabr, Navoiy, O'zbekiston 102-104 b.
12. Холиков, К. М., Шогофуров, Ш. Ш., Журабоев, А. Т., Мусаев, Н. М., & Муқимов, М. М. Quality Assessment of Two-layer Refined Knitting. Jour of Adv Research in Dynamical & Control Systems, 12.
13. Shaxbozjon Shogofurov, Mamurjon Ergashev, Xakimjon Xamdamov, Nozima Salayeva, Kurbanali Kholiqov, Xadicha Mamatova; Complex

World Bulletin Publishing
Online Publishing Hub

World Bulletin of Education and Learning (WBEL)

ISSN (E): 3072-175X | Volume 2, Issue 9, September 2026

https://worldbulletin.org/index.php/1

evaluation diagram of backed knitted fabric. AIP Conf. Proc. 23 June 2023; 2789 (1): 040124.

14. Shaxbozjon Shogofurov, Gulshan Musaeva, Xakimjon Xamdamov, Nozima Salayeva, Kurbanali Kholiqov, Xadicha Mamatova; Complex evaluation of knitted fabric obtained on a flat needle machine. AIP Conf. Proc. 23 June 2023; 2789 (1): 040125.
15. Jurabayev, N., Shogofurov, S., Kholikov, K., & Meliboev, U. (2021). Study of the fabric structure influence on the physical-mechanical and technological properties of knitted products. In E3S Web of Conferences (Vol. 304, p. 03030). EDP Sciences.
16. Shaxbozjon Shogofurov, Rustamjon Oxunov, Durdona Hojimatova, Azizbek Turgunov, Kurbanali Kholiqov; Mathematical modeling of the elongation of a knitted fabric. AIP Conf. Proc. 23 June 2023; 2789 (1): 040131.
17. Shaxbozjon Shogofurov, Nematjon Yokubjanov, Jamshid Borotov, Shohabbos Dedaboyev, Kurbanali Kholiqov; Complex assessment of mixed knitted fabric. AIP Conf. Proc. 23 June 2023; 2789 (1): 040021.
18. Komola Murodxodjaeva, Naima Sodiqova, Patxillo Siddiqov, Dilrabo Nazarova, Maxnuza Jalilova, Shaxbozjon Shogofurov; Some peculiarities of the production of fabrics with large patterns using the coordinate method. AIP Conf. Proc. 11 March 2024; 3045 (1): 030041.
19. Shaxbozjon Shogofurov, Xakimjon Xamdamov, Durdona Hojimatova, Mamurjon Ergashev, Jamshid Borotov; Analysis of textile technologies and physical-mechanical devices produced by HpQDS software on flat needle knitting machines. AIP Conf. Proc. 11 March 2024; 3045 (1): 030044.
20. Rahmatova Sadoqat Umarjonovna., Scientific Approach to Considering Properties in the Design of Garments Made from Knitted Fabrics., Scientific and Technical Journal Namangan Institute of Engineering and Technology Volume 10 Issue 4 2025 44-47 bet.
21. Rahmatova Sadoqat Umarjonovna., Technology for obtaining knitted fabrics from various raw materials., Volume 10 Issue 4 2025 48-53 bet.
22. B.B. Nizamova, Q.M. Xoliqov, S.U. Rahmatova., Yassi ikki ignadonli trikotaj mashinalarning texnologik imkoniyatlari va olingan trikotaj

World Bulletin Publishing
Online Publishing Hub

World Bulletin of Education and Learning (WBEL)

ISSN (E): 3072-175X | **Volume 2, Issue 9, September 2026**

https://worldbulletin.org/index.php/1

to‘qimalarning tahlili., Фарғона давлат техника университети И л м и й – т е х н и к а журнали., Scientific-technical journal (STJ FerSTU, ФарДТУ ИТЖ, НТЖ ФерГТУ, 2025, Т.29.спец.выпуск №19) 190-192.

23. Rahmatova Sadoqat Umarjonovna., Theoretical Study of the Quality Indicators of Newly Structured Knitted Fabrics Based on a Mathematical Model., Scientific and Technical Journal Namangan Institute of Engineering and Technology Volume 10 Issue 3 2025., 65-70 pages.
24. Rakhmatova Sadoqat Umarjonovna., Research on the Technology of Producing New-Structure Knitted Fabric Materials and their Physical and Mechanical Properties., “To‘qimachilik va moda sanoatida ilm-fan va innovatsiyalar” ilmiy texnika jurnali www.namdtu.uz ISSN 3030-3788 №5/2025 158-163 bet.
25. Rahmatova Sadoqat Umarjonovna., Trikotaj to`qima matolarining ishlab chiqarish texnologiyasini takomillashtirish yo`llari., 2025-yil 23-24 oktyabr kunlari Namangan davlat texnika universitetida “O‘zbekiston yengil sanoati raqobatbardoshligini oshirish dolzarb masalalari: innovatsion yechimlar va raqamli integratsiya” mavzusidagi Respublika ilmiy-amaliy anjumani//Maqolalar to`plami 1-tom 84-86 bet Namangan 2025.