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Research Article

Study the Correlation Between Needle Size, Thread Size and Stitch Density to Seam Properties on Weave Fabric

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ABSTRACT

In industrial garment manufacturing, various factors affect the quality of finished products. This has led to many challenges and difficulties in product quality management and assurance. The quality of seams is a crucial factor in determining the quality of textile and garment products. This study examines the correlation between needle size, thread size and stitch density to seam properties on satin weave fabric. The study assesses the tensile strength and aesthetics of seams and stitch density using lockstitch 301. It also includes a visual analysis of the seam appearance on the satin weave fabric. A simulation was conducted to evaluate the seam quality and thread density by varying the order of the research objects from two thread types, three needle types, and three stitch density levels. Analysis and evaluation were conducted using the Strip method as per ISO 13935-1 and JISL 1093. The results of the study show a strong connection between the size of the needle, the size of the thread, and the density of the stitch to the properties of the seam on satin woven fabric.

This connection can provide economic advantages, lessen risks, and guarantee quality by reducing errors and imperfections such as wrinkling on the seam surface, cracks on the fabric surface, and needle marks on the fabric surface. It would be incredibly advantageous to create a comprehensive database that documents the correlation between various types of needles, threads, and technical specifications of different fabrics. This database could then be used as a reference by fabric and accessories manufacturers, garment manufacturers, retail brands, and other stakeholders when selecting data. By doing so, it would help establish trust during collaboration.

Keywords: Needle Size, Thread Size, Stitch Density, Satin Weave Fabric, Tensile Strength, Seam Appareance.

INTRODUCTION

In industrial garment manufacturing, various factors affect the quality of finished products.

This has led to many challenges and difficulties in product quality management and assurance. The quality of seams is a crucial factor in determining the quality of textile and garment products. This study examines the correlation between needle size, thread size and stitch density to seam properties on satin weave fabric. The study assesses the tensile strength and aesthetics of seams and stitch density using lockstitch 301. It also includes a visual analysis of the seam appearance on the satin weave fabric. A simulation was conducted to evaluate the seam quality and thread density by varying the order of the research objects from two thread types, three needle types, and three stitch density levels. Analysis and evaluation were conducted using the Strip method as per ISO 13935-1 and JISL 1093. The results of the study show a strong connection between the size of the needle, the size of the thread, and the density of the stitch to the properties of the seam on satin woven fabric.

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In 2022, Bahar TÍBER and Nursel YILMAZ and their research team demonstrated higher seam performance values when performing a horizontal seam with single chain stitches at a density of 4 stitches per centimeter [1]. Meanwhile, Usha Chowdhary and Donna Poynor investigated the impact of three stitch densities on seam efficiency, seam strength and seam elongation of 6–8 stitches per inch, 10–12 stitches per inch, and 14–16 stitches per inch, respectively [2]. Another study on the impact of different stitch densities on seam strength, seam efficiency, and seam puckering was conducted on Oxford, Poplin, and Flannel fabrics by Mohammad Jaber and Md. Mazharul Islam [3].

The surveys and study on satin weave fabrics reveal that this material is quite unique due to its weaving structure, which is characterized by very loose density, thinness, and lightness. These factors pose challenges during sewing, as they can easily lead to seam puckering, fiber disruption, needle hole enlargement, and fabric breakage. Selecting sewing threads, needles, and stitch density for satin woven fabric products based on traditional practices remains a challenge. Garments made from this type of fabric, such as bridal gowns, evening gowns, etc., are products that often require high mechanical durability. Hence, the type and density of sewing thread play a particularly crucial role and are closely related to the appearance of the seam.

THEORETICAL BASIS

Properties of satin weave fabrics

Satin woven fabrics are commonly used in everyday wear, sleepwear, and high-end fashion [4]. Satin woven fabrics can be made from a variety of natural fibers such as cotton and wool, or synthetic fibers such as viscose, polyester, and nylon. However, this study only focuses on the properties of polyester fibers because they produce a characteristically glossy, smooth or lustrous sheen and drape to the fabric, while also being more affordable and having lower production costs compared to fabrics made from the other above-mentioned fibers [5].

Properties of sewing thread

Some basic properties of sewing thread that people often consider are twist, fineness, tensile strength, elongation, friction, and heat stability when sewing. Sewing thread must possess the aforementioned properties as the properties of sewing thread significantly impact the strength, stability, colorfastness, and aesthetics of seams throughout the sewing process, post-sewing, and during the product's lifespan. [6], [7]. During the process of forming a seam, the sewing thread is subjected to tensile stress, as well as friction from the needle, fabric, and thread guides of the sewing machine. After seam formation, the tensile strength of the thread's structure decreases by 10 to 40% [8]. Sewing thread can experience significant heating during high-speed sewing operations due to the rapid rubbing and friction it encounters against the needle, causing a rise in temperature at the contact point. When sewn products, such as clothing, are used and washed, the thread can experience wear and tear, repeated stretching and twisting, as well as exposure to chemicals, which can cause thread breakage and seam loosening.

Characteristics of sewing needles

In the sewing process, the needle is an essential tool that plays a vital role in guiding the thread through layers of fabric and working together with other components to form intricate stitches. Sewing involves a wide range of needles that are designed for specific fabric types and applications. Therefore, it is important to conduct thorough research to identify the most suitable needle for a particular sewing machine and fabric combinations. The needle size is a number that represents the diameter of the needle shaft, indicating the size of the needle. This is a standardized parameter used for all types of needles. The needle number is written on the needle hub and does not depend on any type of needles. The needle tip design varies based on the material, ensuring optimal seam quality and appearance after sewing. In industrial sewing, needle tips are broadly categorized into two main types: round point and sharp point, each designed to suit the specific characteristics of woven and knitted fabrics. The oval point needle tip is a specialized type specifically designed for applications in the leather and footwear industries. The coating material on the needle tip is a layer of metal or alloy applied to the outside of the needle tip. The purpose of coating the outside of the needle tip is to enhance the needle's durability and performance when working on hard, rough, or multi-layered fabric products during sewing process. In addition, coating the needle tip also helps to manage the needle's heat resistance resulting from friction with the sewing material during processing. Several kinds of coatings are applied on the outside of the needle tip, such as nickel, chrome, Teflon, and titanium nitride. The size of the needle eye is

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proportional to the size of the needle shaft and the sewing thread. The larger the needle shaft, the larger the needle eye.

Characteristics of lockstitch seams

The study conducted on the lockstitch seam, the lockstitch 301 seam construction on bridal gowns, showed that this lockstitch is often used to connect parts. The 301 lockstitch is a type of stitch formed by one thread of a needle and one thread of a bobbin, to form interlocking stitches located in the center of the two fabric layers. The advantages of using these stitches are that they are difficult to slip, resulting in high joint strength, a relatively consistently straight and even seam line, and efficient use of thread. These stitches are able to withstand mechanical impact, and have the ability to securely join multiple layers of fabric.

A method for evaluating the quality of seams

The quality of industrial seams is evaluated based on a comprehensive set of factors such as tensile strength, elongation, stitch, and needle hole enlargement, skipped stitches, bending stiffness, puckering, and abrasion resistance of the seam [9]. When it comes to ensuring the aesthetics of a sewn product, mechanical durability and appearance stand out as two of the most crucial factors. The durability of a seam is determined by a combination of factors, including the type of thread, thread strength, stitch density, and sewing needle size [10].

Factors that can impact the appearance of seams

The appearance of a seam is affected by various factors, such as the stitch and seam pattern consistency, seam flatness, needle type, and thread size, etc. [11].

Stitch and seam uniformity refers to the strict standard used to ensure that the shape of a garment is consistent and precise. Different stitch densities, stitch-seam irregularities, loose threads, and loose thread tension can all affect the appearance of a garment. The combination of high stitch density, continuous thread curvature along the seam line, and low thread tension can contribute to minimizing seam puckering. On the contrary, the combination of low stitch density, reduced thread curvature along the seam line, and high thread tension can increase the likelihood of seam puckering.

The appearance of the seam is affected by the type and size of the needle used. Choosing a needle that is too large or incompatible with the fabric can result in fabric damage, fiber breakage as well as needle hole enlargement.

The size of the thread has a significant impact on the strength and durability of a seam. Additionally, it also affects the overall appearance of the seam. If the thread size is too large compared to the material, it can cause fabric breakage, needle hole enlargement, seam puckering, and fiber disruption.

Materials

The experimental fabric was satin weave fabric, 100% polyester. The fabric's weight was 175g/m², 75*300 count. The fabric had an elasticity of ± 2.5%, and its cutting direction was shown in Figure 1. The simulation showed that the seam direction will be vertically aligned with the seams at the assembly positions i.e the seam line was aligned with the warp direction, as compared to the actual product.

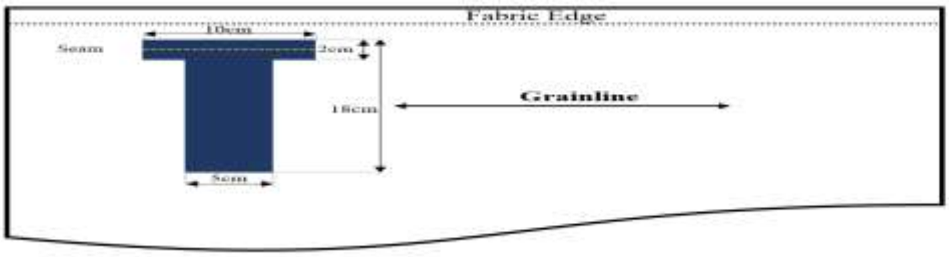

Figure 1. Fabric cutting direction is simulated

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100% polyester core-spun thread was the most common type of sewing thread used in this study. This type of thread was not only more durable for the seam in terms of mechanical durability but it was also more affordable than other types [12]. Two types of 100% polyester threads from Amman company which were used for the experiment had the following basic parameters.

TABLE I. THE TECHNICAL PARAMETERS OF THE SEWING THREAD USED IN THE EXPERIMENT WERE PRESENTED

Parameters	Tex 21	Tex 24
Thread name	Saba	Saba
Brand name	Amann	Amann
Composition	100% Polyester	100% Polyester
Thread number	100/2	120/2
Tex	21	24

Sewing needles from the Groz-Beckert with the following parameters were used in the experiment.

TABLE II. THE TECHNICAL SPECIFICATIONS OF THE SEWING NEEDLES USED IN THE EXPERIMENT WERE PRESENTED

Parameters	A size 8 needle	A size 9 needle	A size 10 needle
Needle system family	DP x 5	DP x 5	DP x 5
Needle size	Nm 60/8	Nm 65/9	Nm 70/10
Needle tip	Basic pointed tip (R)	Basic pointed tip (R)	Basic pointed tip (R)
Coatings	Chrome	Chrome	Chrome

The stitch density corresponds to a tight thread density of 3,5 stitches per centimeter, a medium thread density of 4,5 stitches per centimeter, and a loose thread density of 5,5 stitches per centimeter.

Experimental equipment

Single-needle lockstitch sewing machines are commonly used to create lockstitch seam. The experimental process was conducted using a JUKI DDL-8700-7 sewing machine with the following specifications: a maximum rotation speed of 5000 revolutions per minute (rpm), maximum stitch length of 4 millimeters (mm), needle bar stroke of 30,7mm, and compatible with DP x 5 and DP x 1 needle systems. The experiment was conducted to determine the tensile strength of seams by pulling seam samples to the destroyed state. The testing was performed on a ZwickRoell tensile testing machine with the following specifications model: Z005 TN, serial number: 059008 with a maximum load of 5KN.

Preparing the experimental samples

The experiment was prepared at the seam research department at Groz-Beckert company. A sample of satin weave fabric was cut to a size of 500mm in width and 250mm in length. Two pieces of fabric were sewn together with an 8mm seam allowance, the lockstitch 301 seam with 1mm topstitch, and at a sewing speed of 4000 rpm to form a fabric band.

Five additional experimental samples were cut using the experimented sewing sample as a guide, each with a width of 100mm and a length of 250mm. The working width of the experimental sample was 50mm, and the working length was 200mm. The two 25mm wide sections along the width of the experimental seam sample as guard areas helped prevent stitch slippage at the width of 50 mm when the seam's tensil strength was determined. For each needle-thread-stitch density combination, five experimental samples would be prepared. The total number of samples was 90.

Evaluation methods for the appearance of a seam

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In order to evaluate and compare the appearance of the seams, the samples were photographed after experimental preparation. The images of the samples were then compiled, compared, and used to select the optimal combination of needle size, thread size, and stitch density.

Methods for evaluating measuring the tensile strength of a material

Samples were prepared, sewn, photographed, and tested for tensile strength using the Strip method under ISO 13935-1 [13], [14]. The temperature and humidity were measured following the TCVN 1748:2007 and ISO 139:2005 standards. The temperature and humidity conditions of the environment were (20 ± 2) ° C and (65 ± 4) %, respectively. The distance between the two grips of the tensile machine was set to (200 ± 1) millimeters; the breaking speed was 100 millimeters per minute. The experimental data measuring tensile strength was compiled, processed using SPSS statistical software to calculate the average value, error, eliminate outliers, and determine coefficients of variation and uncertainty, and draw a comparison chart.

RESEARCH RESULTS

The process of observing and evaluating the appearance of seams during experiments with different threads, needles, and stitch densities was made.

For the Tex 21 thread,

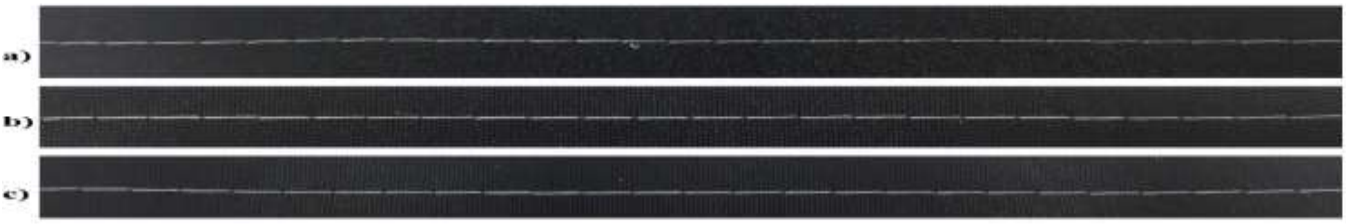

Figure 2. Image of seam appearance sewn with a) A size 8 needle b) A size 9 needle, c) A size 10 needle using Tex 21 thread at stitch density of 3,5 stitches per centimeter

Only the sample sewn with a size 8 needle, and a size 9 needle using Tex 21 thread at stitch density of 3.5 stitches per centimeter met the aesthetic requirements of even, flat seams and less puckering. Needle holes in samples sewn with a size 10 needle were larger and more visible.

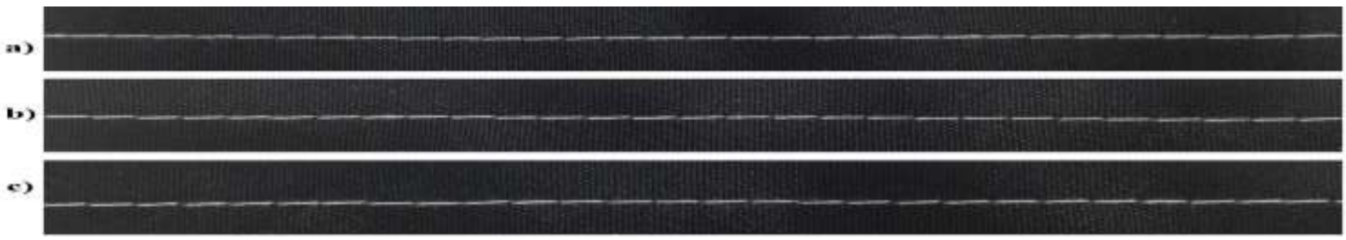

Figure 3. Image of seam appearance sewn with a) A size 8 needle b) A size 9 needle, c) A size 10 needle using Tex 21 thread at stitch density of 4,5 stitches per centimeter

Fabric puckering occured at a stitch density of 4.5 stitches per centimeter for all three needle sizes. However, samples sewn with needle 8 showed less puckering.

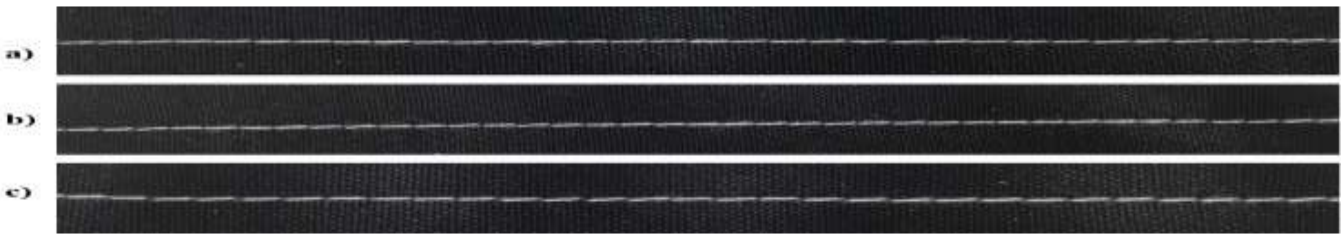

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Figure 4. Image of seam appearance sewn with a) A size 8 needle b) A size 9 needle, c) A size 10 needle using Tex 21 thread at stitch density of 5,5 stitches per centimeter

Fabric puckering increases at a stitch density of 5,5 stitches per centimeter for all three needle sizes; however, a size 8 needle still exhibits less puckering.

For the Tex 24 thread,

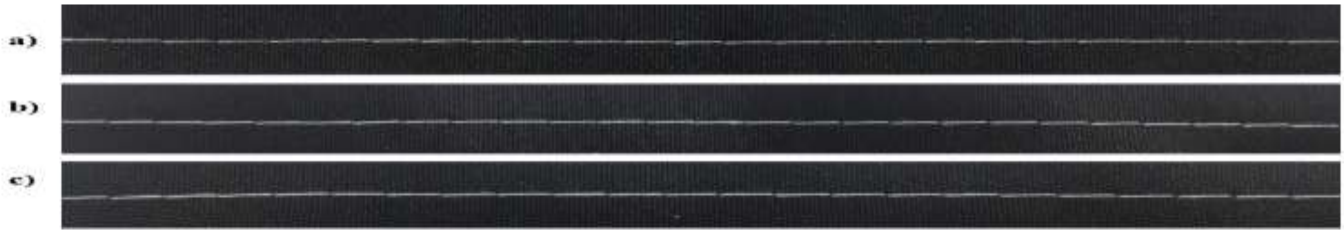

Figure 5. Image of seam appearance using Tex 24 thread, at stitch density of 3,5 stitches per centimeter using different needle sizes

Only the sample sewn with a size 8 needle at stitch density of 3,5 stitches per centimeter met the aesthetic requirements of even, flat seams and less puckering. Fabric puckering became more pronounced with larger needle sizes (9 and 10) suggesting that the needle size itself could play a role in fabric distortion, fiber disruption, and puckering when the fabric is penetrated. Regarding the needle hole issue, needle holes in samples sewn with a size 10 needle were larger and more visible than those sewn with a size 8 needle and a size 9 needle. The stitches also tended to be skewed and misaligned when sewn with a size 10 needle.

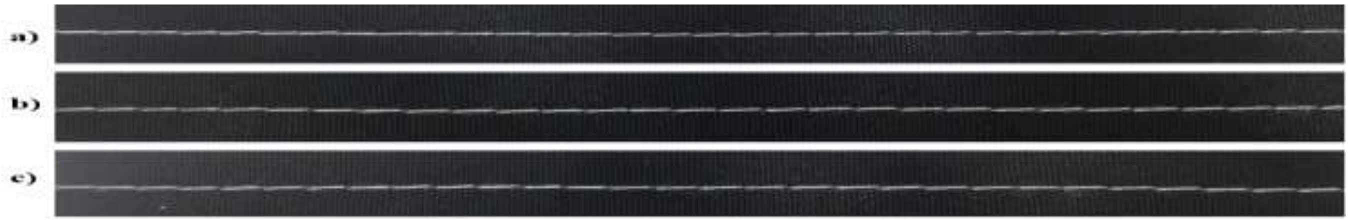

Figure 6. Image of seam appearance using Tex 24 thread, at stitch density of 4,5 stitches per centimeter using different needle sizes: a) A size 8 needle, b) A size 9 needle, c) A size 10 needle

At a stitch density of 4,5 stitches per centimeter, puckering was observed when all three needle sizes were used. However, the puckering was less pronounced in the samples sewn with size 8 and 9 needles than in the samples sewn with a size 10 needle. Needle holes in samples sewn with a size 10 needle were larger and more visible and the stitches were more skewed and misaligned.

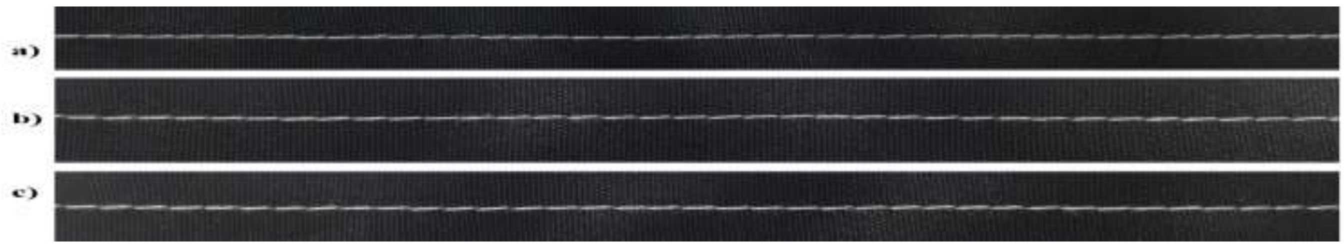

Figure 7. Image of seam appearance using Tex 24 thread, at stitch density of 5,5 stitches per centimeter using different needle sizes: a) A size 8 needle, b) A size 9 needle, c) A size 10 needle

At a stitch density of 5,5 stitches per centimeter, puckering became more evident when all three needle sizes were used. The sample sewn with the size 10 needle exhibited particularly noticeable puckering. Additionally, the size 10 needle produced larger, more visible needle holes, misaligned stitches, and an overall bumpy seam appearance.

The experimental results indicated that a size 8 needle consistently outperformed the other needle sizes in all cases when combined with different thread and stitch density combinations. Larger needle sizes caused greater disruption

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to the fiber structure as the needles penetrated the material, leading to more pronounced puckering, and leaving larger needle holes on the fabric surface and this issue could become more severe in large-scale industrial production, and might damage fabric surface especially when sewn at high speeds. Based on the experimental and comparison results, a size 8 needle emerged as the most suitable choice for satin woven fabrics.

Considering thread size and stitch density, the limitations observed at a stitch density of 5,5 stitches per centimeter for both Tex 21 and Tex 24 threads were increased puckering, fiber distortion, and enlarged needle holes in experimental samples sewn with all three needle sizes. Only the sample sewn with a size 8 needle using Tex 24 thread at stitch density of 3,5 stitches per centimeter, and at stitch density of 4,5 stitches per centimeter met the aesthetic requirements of even, flat seams and without puckering. Meanwhile, using finer threads (Tex 21) at stitch density of 3,5 stitches per centimeter and at stitch density of 4,5 stitches per centimeter for the samples, with size 8 and size 9 needles met the aesthetic requirements.

Based on the analysis results, a comparison on the appearance of the experimental samples was made and shown in the following table.

TABLE III. THE COMBINATIONS MARKED WITH "X" REPRESENT THE EXPERIMENTAL SAMPLES THAT EXHIBITED UNSATISFACTORY AESTHETIC QUALITY

Thread size	**Needle size**	**Stitch density (stitch per centimeter)**		
		3,5	**4,5**	**5,5**
Tex 21	8			x
	9			x
	10	x	x	x
Tex 24	8			x
	9		x	x
	10	x	x	x

Evaluation results of tensile strength of seams using each type of thread size, needle size, and stitch density following Strip method

The test results for the tensile strength of seams on satin woven fabric when sewn with Tex 21 and Tex 24 threads under varying needle sizes and stitch densities were presented in two charts, labeled Chart 1 and Chart 2, respectively.

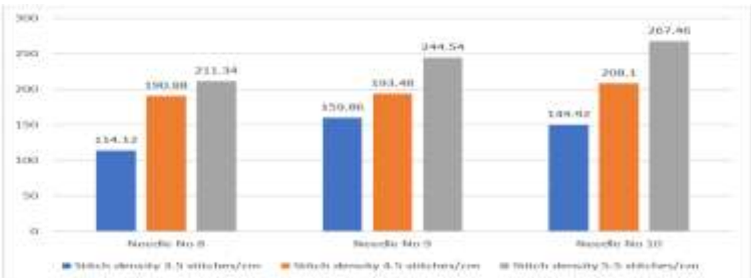

Figure 8. The chart presented the average tensile strength of seams sewn with Tex 21 thread on satin weave fabric under different needle sizes and stitch densities

When using Tex 21 thread, all three samples sewn at a stitch density of 3.5 stitches per centimeter (cm) exhibited tensile strength values lower than 160 Newtons (N). When the stitch density was increased to 4.5 stitches per centimeter (cm), the maximum force required to break the seam reached 244,54 Newtons (N), and this was achieved when using a size 9 needle. When the stitch density was increased to 5.5 stitches per centimeter (cm), all the samples tested showed tensile strength values of 211,34 Newtons (N) or higher.

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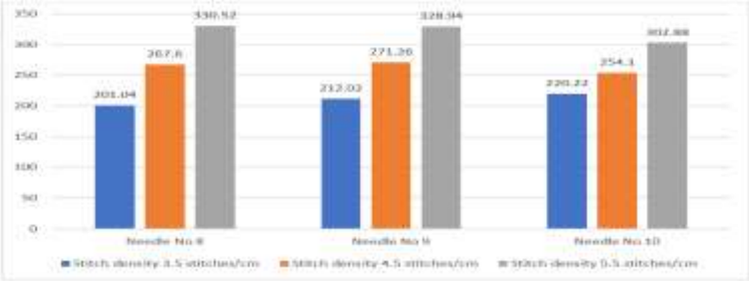

Figure 9. The chart presented the average tensile strength of seams sewn with Tex 24 thread on satin weave fabric under different needle sizes and stitch densities

When using Tex 24 thread, all the samples tested showed tensile strength values of 200 Newtons (N) or higher. The maximum tensile strength at a density of 3,5 stitches per centimeter was 220,22N, similarly for the sample sewn at a density of 4,5 stitches per centimeter is 271,26N and for the sample sewn at a density of 5,5 stitches per centimeter was 330,52N, respectively.

Based on the experimental results, among the two types of threads with different thread numbers used on satin weave fabric using different needle sizes and stitch densities, the method for testing seam tensile strength following the Strip method showed that under the same needle size and thread number, all samples using Tex 24 thread have higher tensile strength than that of those using Tex 21 thread.

The impact of stitch density on the tensile strength of seams was based on the experimental results for three stitch densities: 3,5 stitches per centimeter, 4,5 stitches per centimeter, and 5,5 stitches per centimeter. The average seam tensile strength of the samples was directly proportional to the stitch density. In other words, the tighter the stitch density, the higher the average seam tensile strength.

Based on the experiment and evaluation of seam appearance, the combination of Tex 21 thread and a stitch density of 5,5 stitches per centimeter met the tensile strength requirement. However, at a stitch density of 5,5 stitches per centimeter, there were aesthetic limitations due to puckering, misaligned fibers, etc. When Tex 24 thread with a stitch density of 5,5 stitches per centimeter was used, the tensile strength factor was well ensured. However, increasing the thread size and sewing at a high density have resulted in enlarged needle holes and more skewed and bumpy seams compared to samples sewn at a density of 4,5 stitches per centimeter.

The combination of Tex 24 thread (number 120/2), Nm 60/8 needle, and 4,5 stitches per centimeter stitch density offered the most suitable balance between mechanical strength, specifically tensile strength, and aesthetic quality for the seams and ensured the overall seam quality.

CONCLUSIONS

Based on the experimental results, comparison charts, and visual observations, here comes the recommendations for thread size, needle size, and stitch density in order to achieve the highest seam quality when sewing a garment from 100% polyester satin weave fabric.

- Suitable thread size - Tex 24 thread with number 120/2
- The most suitable needle size is Nm 60/8
- Suitable stitch density is 4,5 stitches per centimeter.

The study has shown correlation between technological parameters of needle size, thread size, and stitch density on the tensile strength and appearance of seams sewn on 100% polyester satin weave fabric. Therefore, choosing the right sewing supplies can contribute to product quality improvement and cost reduction for garment manufacturers by about 3%.

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REFERENCES

[1] B. Tiber and N. Yılmaz, "Investigation of the Effects of Elastic Sewing Thread on Seam Performance Properties of Stretch Denim Fabrics", Textile and Apparel, vol. 32, no. 1, pp. 47-56, 2022, DOI:10.32710/tekstilvekonfeksiyon.921511.

[2] Usha Chowdhary and Donna Poynor, "Impact of stitch density on seam strength, seam elongation, and seam efficiency", International Journal of Consumer Studies, vol. 30, no. 6, pp. 561-568, 2006, DOI: https://doi.org/10.1111/j.1470-6431.2005.00479.x

[3] Mohammad Jaber, "Investigating Seam Strength & Seam Performance with Different SPI on Different Fabrics", IOSR Journal of Polymer and Textile Engineering (IOSR-JPTE), vol. 6, no. 2, pp. 32-41, 2019, DOI: 10.9790/019X-06023241.

[4] S. Stankard, "Textiles and Fashion", Woodhead Publishing, pp. 255-287, ISBN 9781845699314, 2015, DOI: https://doi.org/10.1016/B978-1-84569-931-4.00011-8

[5] Manal A. Self, "Investigating the seam slippage of satin fabrics", International Journal of Textile and Fashion Technology (IJTFT), Vol. 4, No. 5, 1-10, 2014.

[6] R. A. and A. Das, "Technical textile yarns", vol. 15, no. 8. Woodheadpublish limited, 2010.

[7] Borse, S., Sonawane, K., V. Kakde, M., & A. Shinde, T., "Review on Analysis of Seam Quality", IntechOpen, 2020, DOI: https://doi.org/10.5772/intechopen.87999

[8] Giorgio Minazio P, "The fabric pressing performance and its role in predicting the appearance of men's wool suit jackets", International Journal of Clothing Science and Technology, pp. 182-190, 1998.

[9] Tuteja, Shweta & Poulomi, Sen, "A Study on the Effect of Sewing Thread Count and Stitch Density on the Seam Performance of Denim Fabric", Journal of the Textile Association, vol. 3, pp. 34-39, 2018.

[10] Nguyen Phuoc Son, Nguyen Thi Tuyet Trinh, "Researching for application of lean production in redesigning sewing workshop layout in ground apparel company, waste reduction, labour productivity enhancement", Journal of Technical Education Science (JTE HCMUTE; ISSN: 1859-1272), pp. 69-77, December 2016.

[11] Nguyen Phuoc Son, Ho Thi Minh Huong, Tran Dai Nguyen, "Motion study application to eliminate redundant loss time in production, reduce wastefulness and improve labor productivity at garment companies", Vietnam Electromechanical Journal (ISSN 2615 - 9910), pp. 193-203, Special issue magazines, December 2021.

[12] Nguyen Phuoc Son, Nguyen Ngoc Chau, Nguyen Thi Tuyet Trinh, "Research and preparation of thinking strategies for quality of textile and garment products manufactured in Vietnam", Proceedings of 6th 2022 International Conference on Green Technology and Sustainable Development (GTSD), pp 292-295, VNUHCM-Press, ISBN 978-604-73-9622-1, 3/2023.

[13] Textiles — Seam tensile properties of fabrics and made-up textile article part 1, E. I. 13935-1, 2014.

[14] Standard Test Method for Failure in Sewn Seams of Woven Fabrics, D1683/D1683M-17, 2017.