(REFEREED RESEARCH)

THE EFFECTS OF SEWING THREAD PROPERTIES ON THE NEEDLE THREAD TENSION IN AN INDUSTRIAL SEWING MACHINE

DİKİŞ MAKİNESİNDE DİKİŞ İPLİK ÖZELLİKLERİNİN İĞNE İPLİĞİ GERİLİMİNE ETKİLERİ

Pınar KONCER, Ayça GÜRARDA, Binnaz KAPLANGİRAY, Mehmet KANIK

Uludag University, Department of Textile Engineering, Bursa, Turkey

Received: 28.06.2013 Accepted: 02.12.2013

ABSTRACT

This paper presents the measurement of the needle thread tension in an industrial sewing machine using various sewing threads. In this work, three types of sewing threads, air-jet textured (PET), core-spun (PET/PET) and (PET)-spun were used. Two lubricant types and two lubricant feeding rates were applied to these sewing threads. The results of this research show that the sewing thread type, lubricant type and lubricant feeding rate have important effects on the tension of the needle thread. The tension values were lowest for all of the sewing thread types using a paraffin-based lubricant. When paraffin wax was used in the lubricant the tension decreased slightly. Paraffin-based lubricants with 1 g/min lubricant feeding rate are suitable for sewing threads to achieve the lowest needle thread tension.

Key Words: Needle thread tension, Sewing thread, Lubricant, Lubricant feeding rate.

ÖZET

Bu çalışma endüstriyel dikiş makinesinde bazı farklı dikiş ipliği özelliklerinde iğne ipliği geriliminin ölçülmesini sunmaktadır. Bu çalışmada, hava tekstüre, core spun (polyester/polyester) ve eğrilmiş polyester dikiş iplikleri olmak üzere üç tip dikiş ipliği kullanılmıştır. Dikiş ipliklerine iki değişik yağlama maddesi ve iki değişik yağ besleme oranı uygulanmıştır. Araştırmanın sonuçları iplik tipi, yağlama maddesi tipi ve yağ besleme oranının iğne ipliği gerilimi üzerinde önemli etkisi olduğunu göstermektedir. Parafin esaslı yağlama maddesi ile yağlanan dikiş ipliklerinin geriliminin diğerleri arasında en düşük değerde olduğu görülmektedir. Yağlama maddelerinde parafin kullanıldığında gerilim düşmektedir. Düşük iğne ipliği gerilimi için 1 g/dak besleme oranlı parafin esaslı yağlama maddesi ile yağlanmış dikiş ipliklerini seçmek en uygundur.

Anahtar Kelimeler: İğne ipliği gerilimi, Dikiş ipliği, Yağ ,Yağ besleme oranı.

Corresponding Author: Ayça Gürarda, aycagur@uludag.edu.tr, Tel :+90 224 294 20 60

1. INTRODUCTION

The tensions generated by the needle and bobbin threads are important factors in determining the quality of a lockstitch seam. Improper tension can cause various problems, such as puckered seams, broken thread and unbalanced seams (1).

The appearance and performance of a seam depend on the quality of the sewing thread and its dynamic behavior. Studies on the dynamic tension in sewing thread have generally intended to improve the seam quality. Although a large amount of research has been and is being conducted on quality control at all stages of garment production, from the thread properties to their dependence on the manufacturing technique used, controlling the tightening tension of the thread during high-speed sewing could improve sewability (2). Modern, high -speed sewing machines require high-quality sewing threads for satisfactory performance.

Although polyester sewing threads have higher strength and durability, their thermoplastic nature makes them susceptible to property changes from the heat generated during sewing. In this respect, threads with sufficient bulk, such as spun and air-jet textured threads, are ideal (3).

Good seams are essential factors in garment quality. The characteristics of a properly constructed seam are strength, elasticity, durability, stability and appearance. The factors governing these properties are the seam and stitch type, thread strength and elasticity, stitches per unit length of seam, thread tension, and seam efficiency of the material (4).

Seam puckering may be caused by overly tight thread tension, which causes the thread to elongate as stitches form. Tight tension settings on the upper or lower threads during either stitching or bobbin winding or damage to the thread guides may cause seam puckering. Bobbin winders may be set too tight to fit more thread on a bobbin and reduce the number of changes necessary.

During sewing, the sewing threads are under some tension. When the thread tension is relieved, the threads start to contract, which decreases the stitch length. If the decrease in the stitch length is greater than the contraction of the fabric within the stitch, the seam will pucker. The amount of thread elongation and contraction depends on the sewing thread composition and tension. Tension puckering is primarily a problem with synthetic threads (4).

The tension on the needle thread during a stitch cycle was measured for the thread between the take-up lever and needle by sensing the deflection of a cantilever beam using bonded foil strain gauges. The natural frequency of the cantilever was approximately 4 kHz (1).

This article measures the needle thread tension in terms of tension variations during a stitch cycle and how different factors such as the thread types and lubricants affect their behavior.

The tension on the needle thread during stitch formation and its effects have been the topic of many investigations. Brain (1974) identified for the needle-thread four major tension peaks of increasing value for the needle thread, each relating to a particular function of the sewing machine: (I) the needle penetrating the cloth, (ii) the rotary hook picking up the needle-thread, (iii) the interlaced threads being pulled off the rotary hook and (iv) the interlaced threads being pulled back through the substrate (5).

While the sewing thread passes through the machine, the needle thread is exposed to various stresses and strains from the guides, tension disks, tension spring, take-up lever, needle eye and sewing material. In the beginning, the compression force of the tension disks, tension spring force, and the take-up lever action all cause the tensile loading of the thread (6).

The obtained needle thread tension traces are similar to those from previous studies. Typically, four significant tension peaks exits in the needle thread tension trace. These peaks will be referred to as peak 1 to peak 4. At peak 1, the main shaft rotation angle is between 0-95°, and the thread take-up lever completes its upward stroke, which draws the slack needle thread through the fabric, pulls the bobbin thread off the bobbin and sets the stitch. At peak 2, the main shaft rotation angle is between 105-150°, and the needle eye penetrates the fabric. At peak 3, the main shaft rotation angle is between 280-325°, and the multipeak effect from the upward movement of the needle thread and consequent tightening of the needle thread loop around the bobbin. At peak 4, the main shaft angle is between 325-355°, the needle thread slips out of the both rotating sewing hook section jib and case holder position bracket (1).

The lubricant type significantly affected the sewing thread friction coefficient. Sewing threads using the SNV lubricant have higher friction coefficients those with SCI lubricant, which contains paraffin (8,9).

2. MATERIAL AND METHOD

2.1. Materials

In this study, three types of sewing threads, air-jet textured (PET), core- spun (PET/PET) and (PET)-spun were used. These threads were prepared in the Durak Textile Factory in Bursa. Two different lubricant types and two different lubricant feeding rates were applied to these sewing threads.

The properties of each sewing thread before applying lubricant are given in Table 1.

Two lubricants with different chemical compositions were supplied by Rudolf-Duraner A.S. (Turkey) and used in the experiments, and their properties are listed in Table 2. One (SNV) was a silicon-based lubricant (polysiloxane) for cold melt applications. The other (SCI) was a silicon-containing paraffin-based lubricant.

Table 1. Properties of the sewing threads before lubricant application

Yarn Type	Yarn Count (dtex)	Twist (T/m)	Tenacity (N/tex)	Elongation (%)	Friction Properties			
					F_{max} cN	F_{min} cN	F_{AV} cN	µ
Air–jet textured (PET)	290	468 Z	0.426	22.18	40.3	29.8	34.65	0.381
Core spun (PET/PET)	195	1160 Z	0.3207	19.41	39.2	21.4	34.73	0.386
(PET)-spun	278	900 Z	0.3627	15.83	39.5	21.3	33.59	0.376

µ: fiber/metal friction coefficient

Table 2. Properties of the lubricants used in this study

Lubricant name	Chemical structure	Viscosity (mPa.s)	Application temperature (°C)
Ruco-Fil SCI	Polysiloxane+paraffin(95/5%)	500-1000	Cold (25 °C)
Ruco-Fil SNV	Polysiloxane	350	Cold (25 °C)

2.2. Methods

The tenacity and elongation values of the sewing threads were measured in an Instron Strength Tester according to the TS 245 EN ISO 2062 standard. The lubricants were applied to these sewing threads under controlled conditions with an OMR (MDTK/C-3) (Italy) winding machine. Two lubricant feeding rates (0.2-1 g/min) were applied to the sewing threads. The lubricant feeding rates were set using a Graf lubrication system (10).

The amount of lubricant on the sewing threads after it is applied on the winding machine under controlled lubricant feeding rate was measured. A Mesdan Oil Exraction Apparatus (Code 273B) was used quickly determine the lubricant content of the threads.

The fiber/metal frictional forces were measured using a Duranax EFI Friction Force apparatus adjusted to a velocity of 5 m/min and 10 m/min. The fiber/metal friction coefficient measurement experiments were performed using a machine entering strain (F_1) of 10 cN contact angle of 180^o between the yarn and metal, and duration of 60 seconds.

The maximum friction force (F_{max}), minimum friction force (F_{min}) and average friction force (F_{AV}) were determined with using this device.

The needle thread tension was measured using a sewing needle tension test system set-up on a Juki DDL-5550 model lockstitch sewing machine in the Uludag University Textile Engineering laboratory. Figure 1 shows this sewing needle tension test system.

The Juki DDL-5550 model lockstitch sewing machine was run at a speed of 2000 rpm to produce a balanced seam with 5 stitches per cm. Woven fabric with warp density 58 threads/cm and weft density 30 threads/cm and 185 g/m^2 weights was sewn. The DB × 1 BP SES NM 80 R needle was used with the threads. The bobbin thread used the same type of thread as the needle thread to prepare the seams.

We used a BTSR model thread tension sensor, which measures tensions between 0-250 g on a Juki DDL-5550 model lockstitch machine, between needle and take-up lever. The tension on the needle thread during one stitch cycle was measured on the thread line between the take-up lever and the needle. We used an incremental encoder to measure the main shaft rotation angle during a stitch cycle. This system provides 45 data points every 8°.

The sensor yields tension values between 1-250 g with a linear output between 0-10 volts. The results were evaluated with a programmable logic control. Data between 0-250 g were collected from the encoder every 8° and the results were recorded in Excel.

3. RESULTS AND DISCUSSION

The frictional forces and friction coefficients of sewing thread are shown in Table 3. This table shows a significant decrease in the fiber/metal friction coefficient after applying the lubricants. The table indicates that the paraffin-based lubricant (Ruco-Fil SCI) decreased the friction coefficient. Both core-spun and (PET)-spun needle threads often must withstand high temperatures and thus require a high level of lubrication. Table 3 shows that increasing the lubricant feeding rate from 0.2 to 1 g/min also increases the amount of lubricant depending on the lubricant and thread type. 1 g/min lubricant feeding rate yielded lower friction coefficients than 0.2 g/min.

Figure 1. Sewing needle thread tension test system set-up on a Juki DDL-5550 model lockstitch sewing machine in the Uludag University Textile Engineering laboratory.

This study yielded four significant peaks for the needle thread tension. At peak 1, the main shaft rotation angle is between 0-48° as the thread take-up lever strokes upward. At peak 2, the main shaft rotation angle is between 60-105° as the needle eye penetrates the fabric. At 120°, the needle penetrates the fabric, and the take-up lever is in the middle of its rotation. At peak 3, the main shaft rotation angle is between 240-288°, and the multi peak effect results from the upward movement of the needle thread and the consequent tightening of the loop around the bobbin. At 288°, the needle is at its highest position. The shaft-rotated needle then moves upward while the take-up lever moves downward. At peak 4, the main shaft rotation angle is between 340-355° as the needle thread slips out of the rotating sewing hook section jib and the case holder position bracket.

The properties of the sewing threads after lubrication are given in Table 3.

3.1. Effect of sewing thread type on the needle thread tension

The most popular sewing threads available today are (PET)-spun and core-spun (PET/PET). The frictional properties of air-jet textured sewing threads are very similar to the spun threads because the presence of numerous loops provides the effect of a spun yarn. Air-jet textured sewing threads provide better locking in the fabric compared to continuous filament threads (3). Figures 6-9 show that the sewing thread type significantly affects the needle thread tension. Figures 6-9 show, core- spun (PET/PET) sewing thread experienced the highest needle thread tension at the main shaft rotation angles of 48°,72°, 256° and 352° during the stitch cycle.

3.2. Effect of sewing thread lubricant type and lubricant feeding rate on the needle thread tension

The figures indicate the sewing thread lubricant type significantly affected the needle thread tension. As figures 6-9 show, paraffin-based lubricant (Ruco-Fil SCI) decreased the needle thread tension.

The effect of varying quantity and type of lubricant finish applied to the different sewing threads is significant. If too much paraffin is applied, it begins to soften due to local heating, from friction and forms an undesirable grease film that increases the friction (6).

Table 3 shows that the lubricant type significantly affected the sewing thread friction coefficient. Sewing threads coated with the SNV lubricant had higher friction coefficients than those using the SCI lubricant, which contains paraffin. These results showed that the SCI lubricant yielded better friction values compared to the pure silicone fluids, due to their paraffin content. Figures 6-9 show that sewing threads coated with the SCI lubricant had a lower needle thread tension than those coated with SNV lubricant. The application of paraffin can reduce the value of μ by approximately 50%.

The lubricant feeding rates generally affected on the thread tensions. Figures 6-9 show that increasing the lubricant feeding rate decreases the needle thread tension.

Table 3. Properties of sewing threads after lubrication

Sewing thread type	Lubricant Type	Lubricant Feeding Rate (g/min)	Lubricant Amount (%)	Thread Tenacity (N/tex)	Thread Elongation (%)	Friction Properties			
						F_{max} cN	F_{min} cN	F_{AV} cN	μ
Air–jet textured (PET)	Ruco-Fil SCI	0.2	0.975	0.4203	21.44	33.1	13.9	17.4	0.167
	Ruco-Fil SCI	1	6.65	0.4202	21.592	17.6	9.4	12.39	0.058
	Ruco-Fil SNV	0.2	1.62	0.4290	21.67	26.8	15.2	17.84	0.174
	Ruco-Fil SNV	1	6	0.4181	21.83	25.4	15.5	18.6	0.188
Core spun (PET/PET)	Ruco-Fil SCI	0.2	1.07	0.4637	18.12	20.7	14.7	18.43	0.185
	Ruco-Fil SCI	1	7.8	0.4373	18.44	17.2	10	13.82	0.093
	Ruco-Fil SNV	0.2	2.25	0.3239	18.64	23.1	16.7	19.89	0.209
	Ruco-Fil SNV	1	10.32	0.3204	19.03	23.7	16.6	19.18	0.197
(PET)-spun	Ruco-Fil SCI	0.2	1.45	0.3506	14.80	20.3	13.5	17.68	0.171
	Ruco-Fil SCI	1	6.3	0.3274	14.41	19.5	12.5	17.02	0.159
	Ruco-Fil SNV	0.2	2.07	0.3396	14.76	24.7	19.2	21.95	0.240
	Ruco-Fil SNV	1	6.9	0.2875	13.68	25.8	18.2	22.15	0.243

μ : fiber/metal friction coefficient

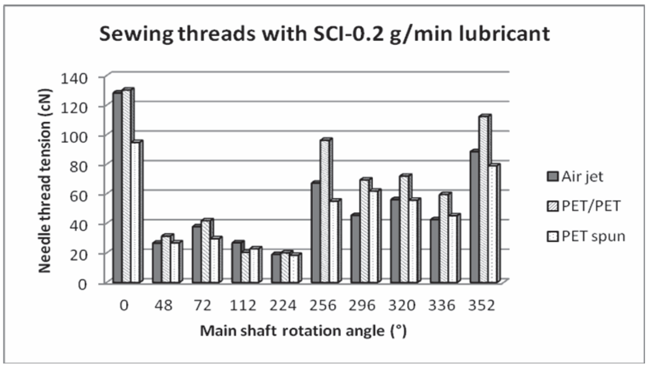

Figure 2. Needle thread tensions of different sewing threads coated with 0.2 g/min of the SCI lubricant versus the main shaft rotation angles for one stitch cycle

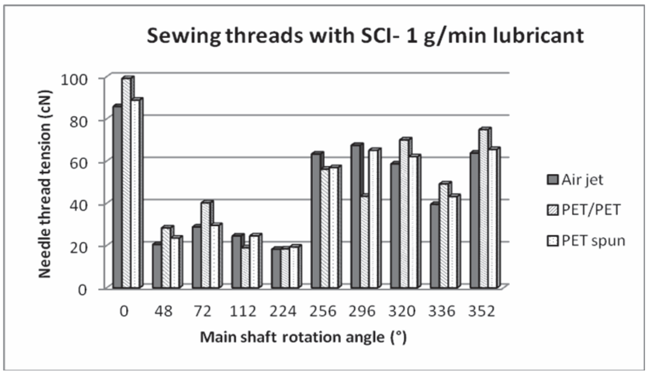

Figure 3. Needle thread tensions of the different sewing threads coated with 1 g/min of the SCI lubricant versus the main shaft rotation angles for one stitch cycle

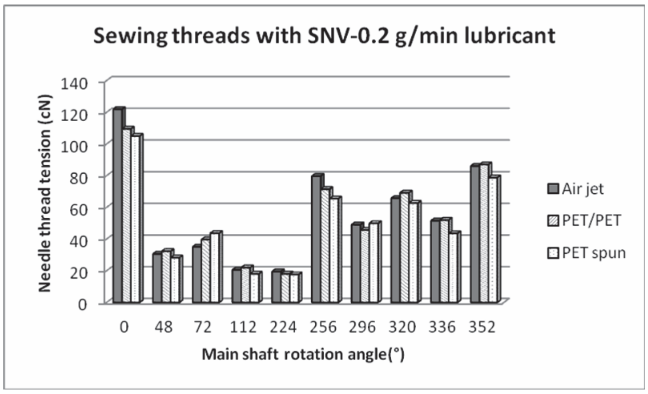

Figure 4. Needle thread tensions of the different sewing threads coated with 0.2 g/min of the SNV lubricant versus the main shaft rotation angles for one stitch cycle

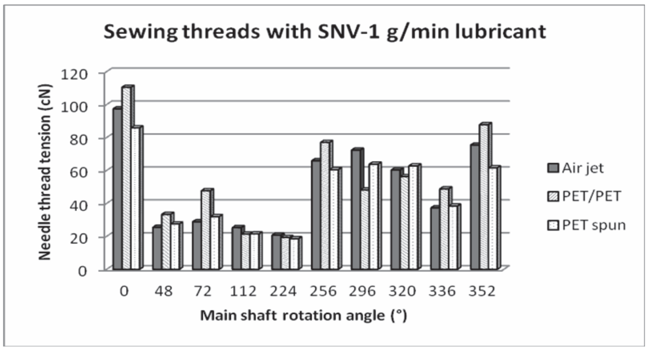

Figure 5. Needle thread tensions of the different sewing threads with 1 g/min of the SNV lubricant versus the main shaft rotation angles for one stitch cycle

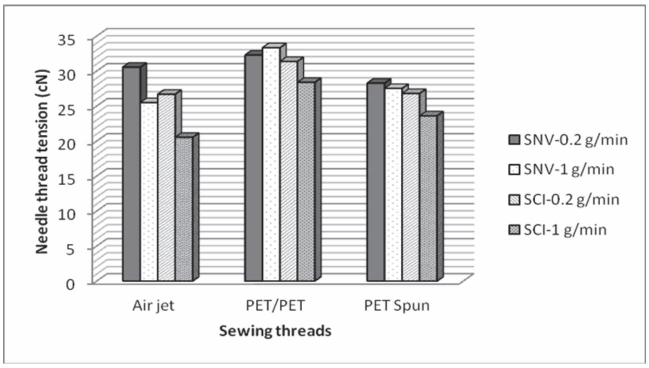

Figure 6. Needle thread tensions of the different sewing threads using the different lubricant types and feeding rates at a main shaft rotation of 48˚

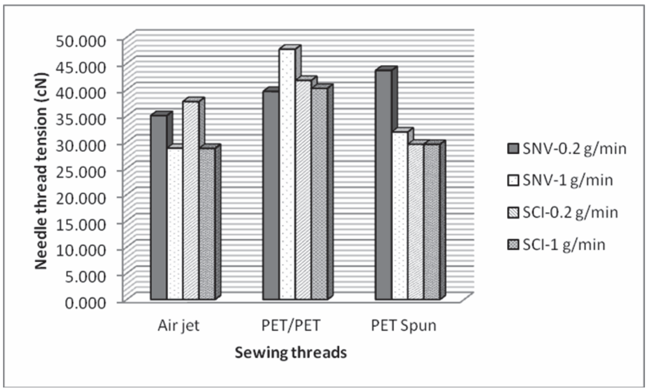

Figure 7. Needle thread tensions of the different sewing threads using the different lubricant types and feeding rates at a main shaft rotation of 72˚

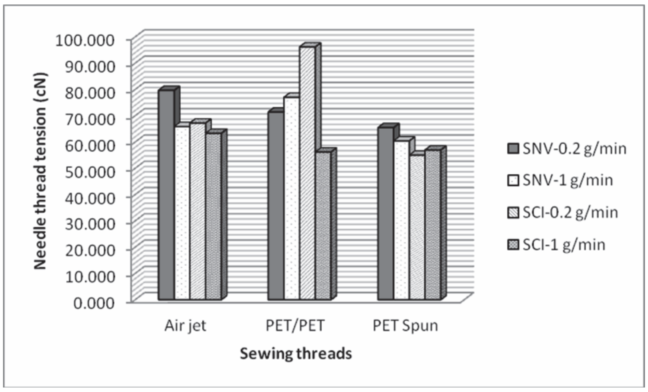

Figure 8. Needle thread tensions of the different sewing threads using the different lubricant types and feeding rates at a main shaft rotation of 256˚

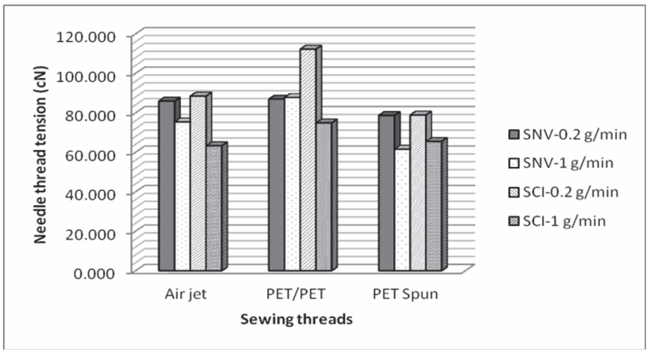

Figure 9. Needle thread tensions of the different sewing threads using the different lubricant types and feeding rates at a main shaft rotation of 352˚

4. CONCLUSIONS

The tension generated in the needle and bobbin threads are an important factor in determining the quality of a lockstitch seam. Improper tensions can cause various problems, such as puckered seams, broken thread and unbalanced seams.

For this reason, we investigated the factors that affected the needle thread tension on a lockstitch sewing machine. Sewing thread types, sewing thread lubricants and lubricant feeding rates are important factors for needle thread tension.

The final aspect of thread construction is that of the surface finish, with the most important finish being lubrication. A lubricating finish applied to a sewing thread should improve the sewability and seam performance. Heat generated by the needle and fabric or the needle and thread is one of the most common sources of seam damage, although it rarely affects synthetic-fiber threads and fabrics, provided that the needle is well designed and made from good-quality steel.

For this reason, we must choose the proper lubricant type and feeding rate to optimize the sewing conditions. This study assists in choosing these proper sewing conditions.

In this study, we investigated the effects that the needle thread tension has on three types of sewing threads using the two lubricant types and feeding rates. It was found that the needle thread tension decreases significantly when paraffin-based lubricant is used.

These results show that the sewing thread, lubricant type and lubricant feeding rate have important effects on the tension of the needle thread. The tension values of all sewing thread types were lowest with the paraffin-based lubricant. The paraffin wax used in these lubricants decreases the tension slightly. It is suitable to use air jet textured (PET) and (PET)-spun sewing threads at 2000 rpm with a paraffin-based lubricant applied at a 1 g/min feeding rate to provide the lowest needle thread tension.

ACKNOWLEDGEMENTS

We gratefully acknowledge the support for this work by the Tübitak 1002 (Project no:112 M008). We are also grateful to Durak Tekstil /Bursa, Turkey for supporting this work.

REFERENCES

1. Ferreira F.B.N., Harlock S.C. and Grosberg P., 1994, "Thread Tensions on Lockstitch Sewing Machine (Part I)", *International Journal of Clothing Science and Technology*, Vol. 6, No 1, pp:14-19.
2. Harrison P.W.,2000, "Sewing Threads",*The Textile Institute, Textile Progress,* Vol. 30, No 3/4, pp:59-61.
3. Nayak R.,Padhye R.,Dhamija S and Kumar V.,2013, "Sewability of Air-jet Textured Sewing Threads in Denim", *Journal of Textile and Apparel Technology and Management,* Vol.8(1), pp:1-11.
4. Baytar F.,2002, "Analysis of Needle Penetration Forces In Lockstitch Sewing Process", MSc Thesis, İTÜ.
5. Laing R.M., Webster J.,1998, "Stitches and Seams", *The Textile Institute*, pp: 17.
6. Midha V.K., Mukhopadhyay A., Chatopadhyay R. and Kothari V.K., 2009, "Studies on the Changes in Tensile Properties of Sewing Thread at Different Sewing Stages", *Textile Research Journal*, Vol. 79(13), pp: 1155-1167.
7. Bamberg M., "Circular Knitting", 1995; pp: 220–221.
8. Gurarda A., Yukseltan E., Kaplangiray B. and Kanık M., 2013, "The Effects of Lubricants on the Frictional Properties of Sewing Threads", *Textile Research Journal*, DOI: 10.1177/0040517512470199.
9. Gurarda A, Kaplangiray B, Kanık M, Yukseltan E., 2011, "The Effects of Lubricants on the Stiffness of Sewing Threads", *Tekstil ve Konfeksiyon*, Vol.21(3), pp: 272-279.
10. http://www.graf-chemie.com/lang-en/produkte/technik/textil/84-graf-lubrication system.html.