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Analysis of the Performance of Sewing Threads Manufactured from Conventional and Compact Ring-spun Yarns

Abstract
The compact spinning system produces a yarn structure which is different from the structure of conventional spun yarn as the result of the elimination of the spinning triangle. New perspectives introduced by compact spinning have proved their worth in all textile processes, from yarn production to the finishing stages. In this study, the seam strengths of sewing threads produced by conventional and compact spun-ring systems were investigated together with strength tests before and after washing. The results were evaluated with SPSS software. It was found out that the difference between the seam strength of sewing threads produced from conventional ring and compact yarns were not of major statistical significance, and nor was the difference in seem strength before and after washing. Additionally, the effect of the gassing process on compact sewing threads was established. The results allow us to recommende that the gassing process should not be applied to sewing threads made of compact yarns.

Key words: *seam strength, compact yarn, sewing thread, gassing.*

Introduction

The compact spinning system produces a yarn structure which is different from the structure of yarn spun by the conventional spinning system yarn structure as a result of the elimination of the spinning triangle. High strength, decreased hairiness and high elongation values are distinctive features of compact yarns. The basic alteration in the compact spinning system, which is the modified form of the ring spinning system, is that the drawing system of compact spinning machine finishes with a condensation zone formed with the aid of air suction. In this way, the spinning triangle is eliminated, which is at the same time the strongest and weakest feature of ring spinning with regard to other systems; thus a better orientation of fibres in the yarn is achieved. Various machine suppliers use different designs of the condensation zone as a result of the elimination of the spinning triangle [1- 3].

The first advantage that comes to mind with the usage of compact spinning system is the decrease in raw material costs. The utilisation ratio of fibre features of compact yarns is higher than conventional ring yarns from the viewpoint of important yarn features such as strength and hairiness. When producers consider profiting from raw material's cost advantage without aiming to increase the yarn quality, it is possible to achieve such a cost advantage by using low-quality raw material [4].

It is possible to produce compact yarns with the same strength as the ring yarns by decreasing the twist amount by 20-25%, because of the high utilisation ratio of the fibre features of compact yarns [5-8]. Decreasing the twist amount allows the production of yarns with the same strength as ring yarns with softer handle, and also directly increases the yarn production speed [5].

In the compact spinning system, eliminating the spinning triangle almost entirely in the yarn formation zone allows even very short fibres to contribute to strength in this zone where fibres have no twist. In this way, the spinning tension existing in this zone is received by all fibres. Thus breakages during yarn production decrease, and therefore the spinning stability increases [9].

When working with compact yarns, the size amount necessary for warp preparation or weaving performance can be decreased by 50% in comparison to ring yarns with the same properties [5, 9 - 11]. A decrease in size amount as a result of the usage of compact yarns also decreases the cost of the desizing process, besides the cost advantage achieved in the sizing process [5].

A high performance of compact yarns on weaving and knitting machines is very important for more economic production of woven and knitted fabrics. Compact yarns, which have high strength and low hairiness, cause fewer fibre flys and yarn breakages. In this way, weaving and knitting machines can be kept clean. Compact yarns enable the finished textile products to have higher strength, a brighter appearance and better handle. The tendency to pill decreases as a result of much lower hairiness [12, 13].

New perspectives introduced by compact spinning have proved their worth in all textile processes from yarn production until the finishing stage. However, the use of compact yarns as sewing threads has not been encountered in the literature we have investigated. The purpose of this study is to investigate and compare the performances of sewing threads as produced by conventional ring and compact yarns. In this study, seam strengths of sewing threads produced by both methods will be measured, and the difference in seam strengths will be statistically analysed. The effect of the washing process on the seam strength will also be observed. Another purpose of this research is to determine the effect of the gassing process on the sewing thread made of compact yarns.

Material and method

In this research, Giza 70 type cotton was used as the raw material for the sewing thread. Single ply yarn was produced from the cotton according to conventional ring and compact spinning systems. Then, the single ply yarn was shaped into sewing thread by passing it through the production steps (rewinding-doubling-twisting-gassing-mercerising-bleaching-dyeing-finishing) of a sewing thread. In order to observe the effect of the gassing process, half of the sewing thread produced from compact yarns was subjected to this process. The test results obtained during production of the sewing thread used in this research are given in Table 1. The right fabric for the count of the sewing thread was selected to investigate the seam strength of the sewing thread produced. For this purpose, we used trouser fabric with a mixture of 50% viscose and 50% polyester, and 245 g/m^2 in weight. The seam strength test was performed on an Instron 4411 device according to the ISO 13935-2 standard [14]. The speed of the device was 100 mm/min. Samples were cut to the dimensions of 100 ×150 mm. Two samples were sewn together on the short side by putting one right above the other. Lock stitch, three thread and five thread overlock seams were selected as seam types. The stitch density was 5 stitches/cm. Trials were made five times for each type in the weft and warp directions separately. With this aim, 180 test samples were prepared. Additionally, a washing test (EN ISO 6330) was performed in order to investigate the effect of the washing process on the seam strength [15]. The number of washing cycles was determined as 10, 20 and 30. The trials were performed based on five repetitions, and the seam strengths were measured after washing. Thread breakages on the sewing machine were also noted to determine the effect of the gassing process on the sewing threads made of compact yarns. A Juki DDL-8500-7 electronic lock stitch machine was used as the sewing machine. A circular fabric band of 25 cm width and 1.5 m length was prepared on the machine. Yarn breakages were noted as 20 m of fabric was sewn at 4500 needle penetrations per minute. 50 repetitions were made for each type of sewing thread. The results obtained were evaluated on a computer with the aid of SPSS software.

Results

The test results of seam strength determined for three different types of sewing thread and three different types of stitch are given in Table 2. Each seam strength average consists of five repetition values. The seam strength values were statistically evaluated with the aid of SPSS software. The significant level α was taken as 0.05 for these evaluations. The variance analysis results of seam strengths of fabrics cut in the warp and weft directions are given in Tables 3 and 4 respectively. When Tables 3 and 4 are examined, the seam strength results in the warp and weft directions are seen to be in agreement with each other. In the factorial experiments (3×3), the difference in the seam strengths of stitch types was found to be statistically important, whereas the difference in the seam strengths of different sewing thread types was insignificant. It is well-known that the seam strength changes according to the stitching type [16, 17]. The goal of this study is to determine the effect of the sewing threads produced by conventional ring and compact yarns on the seam strength. According to the results of the variance analysis, the difference in the seam strengths of sewing threads made of conventional ring and compact yarns

Table 1. Test results of sewing threads production methods used in various production stages.

Parameter	Single ply		After twisting		Sewing cone		
	Conventional ring	Compact	Conventional ring	Compact	Conventional ring	Compact gassed	Compact without gassing
Yarn count(tex)	15	15	45	45	45	45	45
Cotton type	Giza 70	Giza 70	Giza 70	Giza 70	Giza 70	Giza 70	Giza 70
Size CV%	0.52	1.20	0.94	0.31	0.95	0.33	0.32
Twist S/Z, t/m	996 S	1020 S	729 Z	711 Z			
Force, cN	364	363	1275	1202	1492	1446	1434
Force CV, %	7.47	6.91	3.27	4.54	5.12	5.98	4.58
Tenacity, cN/Tex	24.33	24.84	27.85	26.87	35.78	35.44	34.14
Elongation, %	4.90	5.66	6.94	7.29	4.83	5.03	4.75
CV, %	11.57	11.01	6.45	6.22	6.29	6.12	4.61
Thin-%50	0	0	0	0			
Thick+%50	9	9	0	0			
Neps+%200	48	21	1	1			
S3 hairiness	2793	600	165	33	20.33	5.83	190
Hairiness index	1070	217	39	5	6.33	0.5	66

Table 2. Seam strength test results.

	Stitching type	Type of sewing thread	Mean, N	Standard deviation
WARP	301 lock stitch	Standard	296.6	29.2
		Compact gassed	290.6	17.2
		Compact without gassing	279.2	15.3
	3 thread overlock	Standard	236.8	24.4
		Compact gassed	236.8	9.2
		Compact without gassing	233.6	17.8
	5 thread overlock	Standard	306.4	19.3
		Compact gassed	273.0	25.1
		Compact without gassing	287.5	25.5
WEFT	301 lock stitch	Standard	297.2	25.7
		Compact gassed	291.4	20.4
		Compact without gassing	281.6	15.7
	3 thread overlock	Standard	193.2	12.1
		Compact gassed	200.6	10.1
		Compact without gassing	198.6	11.7
	5 thread overlock	Standard	297.0	14.2
		Compact gassed	273.4	9.4
		Compact without gassing	283.2	27.8

Table 3. *Variance analysis according to seam strength in the warp direction.*

Source	Sum of squares	df	Mean square	F	Sig
Stitching type	27874.2	2	13937.1	31.50	0.000
Type of sewing thread	1706.3	2	853.1	1.93	0.161
Stitching type * Type of sewing thread	1881.4	4	470.4	1.06	0.389
Error	15488.2	35	442.5	-	-
Total	47085.2	43	-	-	-

Table 4. *Variance analysis according to seam strength in the weft direction.*

Source	Sum of squares	df	Mean square	F	Sig
Stitching type	80929.9	2	40465.0	131.68	0.000
Type of sewing thread	591.1	2	295.6	0.96	0.392
Stitching type * Type of sewing thread	1582.9	4	395.7	1.29	0.293
Error	11064.4	36	307.3	-	-
Total	94168.3	44	-	-	-

Table 5. *Results of seam strength before and after washing.*

	Washing	Type of thread	Mean, N	Standard deviation
WARP	Before washing	Compact gassed Standard Compact without gassing	290.0 271.8 255.2	20.1 16.0 15.6
	10 washings	Compact gassed Standard Compact without gassing	280. 2 270.4 273.7	18.0 31.7 12.9
	20 washings	Compact gassed Standard Compact without gassing	275.4 304.0 264.4	9.6 21.3 28.3
	30 washings	Compact gassed Standard Compact without gassing	259.8 281.6 286.6	17.3 17.6 29.2
WEFT	Before washing	Compact gassed Standard Compact without gassing	274.8 274.2 278.6	12.5 19.2 20.5
	10 washings	Compact gassed Standard Compact without gassing	275.4 278.2 272.0	12.4 19.0 7.8
	20 washings	Compact gassed Standard Compact without gassing	243.0 260.8 273.4	26.5 24.0 19.5
	30 washings	Compact gassed Standard Compact without gassing	275.2 264.4 276.4	17.6 12.7 25.9

Table 6. *Variance analysis (in the warp direction, after washing, according to seam strengths).*

Source	Sum of squares	df	Mean square	F	Sig
Stitching type	637.4	3	212.5	0.48	0.695
Type of sewing thread	1388.2	2	694.1	1.58	0.217
Stitching type * Type of sewing thread	8025.6	6	1337.6	3.04	0.013
Error	20657.9	47	439.5	-	-
Total	30778.9	58	-	-	-

Table 7. *Variance analysis (in the weft direction, after washing, according to seam strengths).*

Source	Sum of squares	df	Mean square	F	Sig
Stitching type	2757.9	3	919.3	2.55	0.067
Type of sewing thread	678.5	2	339.3	0.94	0.398
Stitching type * Type of sewing thread	2244.5	6	374.1	1.04	0.413
Error	17318.0	48	360.8	-	-
Total	22998.9	59	-	-	-

was not of major statistical significance. The strength superiority of compact yarn over ring yarn which is expressed in some publications is not observed distinctively between the sewing threads produced under the same conditions in this research [4 - 9]. This makes us think that the use of Egyptian cotton with long fibres in the production of the sewing threads used in the research may be the reason. The difference in strength between the compact and ring yarns can be observed more clearly when the production is made with the cotton with lower average fibre length and degree of uniformity.

In the second stage of the research, the effect of the washing process on the seam strength was investigated. With this aim, 60 test samples were prepared. These samples were sewn on the Juki DDL-8500-7 lock stitch machine with three different sewing threads. At this stage of the trials, only lock stitch was used. After sewing, the samples were classified into four groups (before washing, 10, 20 and 30 washing cycles). The seam strength results before and after washing are shown in Table 5. Each seam strength average consists of five repetition values. A variance analysis was conducted to examine the difference in seam strengths of each sewing thread at every washing cycle and between washings. The results of the variance analysis for the warp and weft samples are given in Tables 6 and 7 respectively. When Tables 6 and 7 are studied, the difference between the seam strengths of each sewing thread type before and after washing was determined to be statistically insignificant.

As a result, it can be concluded that the washing process does not influence seam strength to a great extent. Moreover, as the number of washing cycles is increased, it was observed that the seam strength also increased. This situation is caused by the shrinkage of fabric during washing. Therefore, the fabric structure becomes tighter, which results in higher seam strength.

The need to examine the effect of the gassing process on the yarn breakages during sewing arose when no differences were seen in the seam strength averages between the sewing threads that were or were not subjected to the gassing process. For this purpose, yarn breakages were noted for each of the three sewing thread types used on the lock stitch machine. The number of yarn breakages was

Table 8. Numbers of sewing thread breakages in line with the type of sewing thread.

Repetition	Standard	Compact gassed	Compact without gassing	Repetition	Standard	Compact gassed	Compact without gassing	Repetition	Standard	Compact gassed	Compact without gassing	Repetition	Standard	Compact gassed	Compact without gassing	Repetition	Standard	Compact gassed	Compact without gassing
1	0	1	0	**11**	0	0	0	**21**	1	0	0	**31**	0	0	0	**41**	0	0	0
2	1	0	0	**12**	1	0	0	**22**	1	2	0	**32**	0	0	0	**42**	0	0	0
3	0	0	1	**13**	0	0	0	**23**	0	0	0	**33**	0	0	0	**43**	0	0	0
4	0	0	0	**14**	0	0	0	**24**	0	0	0	**34**	0	0	0	**44**	0	0	0
5	0	0	0	**15**	0	2	0	**25**	0	1	0	**35**	0	0	0	**45**	0	0	0
6	0	0	1	**16**	0	0	0	**26**	0	0	0	**36**	0	0	0	**46**	0	0	0
7	1	0	0	**17**	0	0	0	**27**	0	0	0	**37**	0	1	0	**47**	0	0	0
8	0	1	0	**18**	0	0	0	**28**	0	0	0	**38**	0	0	0	**48**	0	0	0
9	0	0	0	**19**	1	0	0	**29**	1	1	0	**39**	0	0	0	**49**	0	0	0
10	0	1	1	**20**	0	0	0	**30**	0	0	0	**40**	0	0	0	**50**	0	0	0

recorded every 20 m, and the results are given in Table 8. The variance analysis was conducted in order to statistically examine the difference between the numbers of yarn breakages. The results of the variance analysis are given in Table 9, which shows that there are no differences between the sewing thread types in terms of yarn breakages. This implies that the gassing process should not be applied to sewing threads made of compact yarns, since the highest yarn breakage was obtained for the compact gassed sewing thread. This shows that it is incorrect to singe the loose fibres on the compact sewing thread, which is classified as hairless yarn, by subjecting it to the gassing process. Additionally, gassing increases the sewing thread cost. As a result of interviews carried out with companies supplying sewing thread, it was realised that the cost of gassing process was around 60 - 80 cents/kg. For this reason, we recommend that companies planning to utilise the compact spinning system should use the sewing thread without applying the gassing process. When working with compact sewing thread, another consequence observed during the yarn breakage test was that less fibre fly accumulated in the upper thread and lower thread zones of the machine (hook, thread guide, etc) with regard to the ring yarn. This shows that less cleaning of the sewing machine will be required when compact sewing thread is used.

Table 9. Variance analysis according to number of sewing thread breakages.

Source	Sum of squares	df	Mean square	F	Sig
Type of sewing thread	0.5	2	0.25	1.74	0.179
Error	20.8	147	0.14	-	-
Total	21.3	149	-	-	-

Conclusion

In this research, we recommend not applying the gassing process to sewing threads produced from compact yarns. This will enable companies producing sewing threads to eliminate the cost of the gassing process when manufacturing sewing threads from compact spun yarns. Additionally, compact sewing threads cause less fly on the sewing machine in the regions where upper and lower threads run (hook, thread guide, etc.). Thus, this will also be advantageous from the point of view of maintenance of the sewing machines.

Acknowledgments

I wish to thank the representatives of the companies that produced the research material, Anteks and Coats Türkiye.

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Received 30.08.2004 Reviewed 26.09.2005