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UZUNLUK SINIFLANDIRMA SİSTEMİNİN KULLANILDIĞI İPLİK TÜYLÜLÜĞÜ TEST CİHAZLARININ KARŞILAŞTIRILMASI

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Abdurrahman TELLİ

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ABSTRACT: Yarn hairiness is an important element of total quality control. Zweigle system and its different versions are widely used commercially in the industry for the determination of yarn hairiness and these devices are only on hairiness. The measurement sensor on them classifies the hairs according to their length. In this research, Zweigle G567 and Uster Zweigle HL400 using the hairiness length classification system were compared. The most important difference between the two devices is that the recommended measuring speed for Uster Zweigle HL400 is eight times higher than Zweigle G567. In the study, thirteen yarns in different structures were used. The hairiness results in each mm were evaluated statistically in the SPSS program. It was observed that there were significant differences between the measurement results of two devices. In the literature, it is stated that there is an increase in the number of hairs with the increase in test speed of the Zweigle series hairiness devices. However, it was found in this study that there was a decrease in the number of hairs in most of the yarns measured in HL400 that use higher test speed. The more surprising result was that the strong correlation was determined between G567 and HL400 although the hair number obtained from devices show significant differences. This shows that the devices gave correlated results according to its operating principle, but the results of two devices operating at different speeds should not be compared with each other on the same test parameters.

Keywords: *yarn hairiness, determination of yarn hairiness, Uster Zweigle HL400, Zweigle G567, yarn quality control*

UZUNLUK SINIFLANDIRMA SİSTEMİNİN KULLANILDIĞI İPLİK TÜYLÜLÜĞÜ TEST CİHAZLARININ KARŞILAŞTIRILMASI

ÖZ: İplik tüylülüğü toplam kalite kontrolünün önemli bir unsurudur. Zweigle sistemi ve farklı versiyonları, iplik tüylülüğünün belirlenmesi için endüstride ticari olarak yaygın olarak kullanılmaktadır ve bu cihazlar sadece tüylülük ölçümü yapmaktadır. Üzerinde bulunan ölçüm sensörü tüyleri uzunluklarına göre sınıflandırmaktadır. Bu araştırmada uzunluk sınıflandırma sistemi kullanan Zweigle G567 ve Uster Zweigle HL400 cihazları karşılaştırılmıştır. İki cihaz arasındaki en belirgin fark, Uster Zweigle HL400 için önerilen ölçüm hızının Zweigle G567'den sekiz kat daha yüksek olmasıdır. Çalışmada farklı yapılarda on üç iplik kullanılmıştır. Her mm'deki tüylülük sonuçları SPSS programında istatistiksel olarak değerlendirilmiştir. İki cihazın ölçüm sonuçları arasında önemli farklılıklar olduğu gözlemlenmiştir. Literatürde Zweigle serisi tüylülük cihazlarının test hızının artması ile tüy sayısında artış olduğu belirtilmektedir. Ancak bu çalışmada, daha yüksek test hızı kullanan HL400'de ölçülen ipliklerin çoğunda tüy sayısında azalma olduğu tespit edilmiştir. Daha şaşırtıcı olan sonuç ise, cihazlardan elde edilen tüy sayısı önemli farklılıklar gösterse de G567 ve HL400 arasında güçlü bir korelasyon bulunmasıdır. Bu, cihazların çalışma prensibine göre ilişkili sonuçlar verdiğini, ancak farklı hızlarda çalışan iki farklı cihazın sonuçlarının aynı test parametreleri üzerinden birbiriyle karşılaştırılmaması gerektiğini göstermektedir.

Anahtar Kelimeler: *İplik tüylülüğü, iplik tüylülüğünün belirlenmesi, Uster Zweigle HL400, Zweigle G567, iplik kalite kontrol*

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1. INTRODUCTION

Yarn hairiness is an important element of total quality control. It is independent of yarn mass and mass variation. It is a complex parameter and is affected by many manufacturing processes. There may be different hairiness even at the top and bottom of the same ring spinning tube. Yarn hairiness is used for many factors such as maintenance of yarn production machines, efficiency of next processes, and final product quality. Excessive yarn hairiness can cause yield losses during manufacturing processes such as sizing, weaving and knitting after yarn manufacturing. This also affects the raw fabric quality and the amount of defects. In addition, excessive yarn hairiness can cause pilling problems in a short time in the final garment. On the other hand, fabric handles are very important and some yarn hairiness is desired for a pleasant handle. Except for special productions, it is estimated that hairs of 1 and 2 mm length generally provide this desired hairiness. This data is provided by the Zweigle system and its different versions. In this system, the number of fibers of different lengths protruding from the yarn body is measured. The S3 value used for the number of fibers 3 mm and above indicates unwanted hairiness.

Zweigle G567 and Uster Zweigle HL400 using the hairiness length classification system is widely used commercially in the industry for the determination of yarn hairiness and these devices are only on hairiness. There has been no change in the basis of the system. The main difference is in test speed. The advised measuring speed of 50m/min in the G567 has increased to 400m/min in the HL400. Another difference is that 12 and 15mm fiber length measurements in the G567 are not included in the calculations in HL400. However, these changes can directly change the measurement results [1].

In literature, studies have been made for older versions of Zweigle regarding different test speeds on the same device. Wang (1997) investigated the effect of test speed on yarn hairiness results in their study. Experimental results showed that the test speed had a significant effect on the number of hairs in different length groups and the total S3 hairiness value. In Zweigle, the measurement is carried out with air pressure. This effect was analyzed by the researcher, stating that the air circulation changes with the speed increase [2]. In another study, it was emphasized that the effect of test speed gives different results in different spinning systems. It has been stated that air resistance and friction contact affect the results [3]. Air circulation and friction directly change the position of the fibers protruding from the yarn body during measurement. In this case, it is indirectly affected by the hairiness results. Even at the same speed, the results may change when factors such as the fineness and stiffness of the fiber change. Results may vary in different spinning systems where the placement of the fibers varies. In the studies conducted in the literature, they stated that hairiness results vary in different device versions of Zweigle in blended yarns and different spinning systems. In some yarns, a negative correlation was also found in different hairiness measurement principles [4, 5].

For such reasons, in a study conducted by Haleem & Wang (2013), device results and manual measurement results were compared. There were complete differences in both the number and distribution of hairs [6]. It has been indicated in the literature that today's systems do not give certain true yarn hairiness [7]. Sun et al. (2017) have suggested a theoretical method to detect angles of yarn hairiness. It was noted by the authors that, given a detectable angle, the upper and lower limits of detectable hairiness lengths could be estimated and this could serve as a specific guide for correcting hairiness results [8]. However, the rapid measurement offered by these devices and the general information about yarn hairiness ensures their continued use in the industrial and academic studies. Numerous studies have used these devices to test the effect of their work. For instance, Uster Zweigle HL400 was used in the studies carried out by Li et al. (2009) and Gordon (2021) to see the effect of the modifications made on the machine on the purpose of reducing the hairiness of the ring yarns [9, 10]. The hairiness results of HL400 were used in detailed evaluations in Liu et al (2020)'s study on improving yarn quality characteristics with false-twisting technique [11]. In another study, the hairiness change in yarns produced in different spinning systems was tested with the HL400 before and after sizing in order to observe the effects of sizing on the quality of different yarn structures [12]. Hairiness test devices were also used in many studies that the effects of different raw materials and different ratios on yarn quality were studied [13, 14]. These testers were used as reference measurements in the evaluation of image processing studies on yarn hairiness [15, 16]. In previous studies, different test speeds were carried out on the same device. Zweigle series instruments were compared with Uster series instruments having different measuring principles. These devices have been taken as reference in many studies to examine yarn hairiness. However, two different devices at different speeds that use the same result parameter (S3) described here have not been compared in the literature. It is not acceptable to have differences between the devices actively used in the sector. For this reason in this study, the results of two devices working on the basically same principle were analyzed and interesting results were encountered.

2. MATERIAL AND METHODS

In the study, thirteen yarns in different structures were used. Yarns are the forms of 50% Cotton (CO) 50% Viscose (CV) raw and dyed yarns in different numbers, single, plied or containing 78 dtex elastane. Information on the yarns used in the study was presented in Table 1.

The hairiness properties of thirteen different yarns were measured Zweigle G 567 and Uster Zweigle HL400 with five specimens per yarn type. The test speed was 50m/min for G567 and 400m/min for HL400. Tests were performed using standard atmospheric conditions according to EN ISO 139. Fiber length measurements are made at 1, 2, 3, 4, 6, 8, 10, 12 and 15 mm in the G567 system. 12 and 15 mm fiber length measurements in the G567 system are not included in the calculations in HL400. Considering this situation, yarns with no hair at 12 and 15 mm in the measurement results in G567 were preferred. Thus, measurements at 1, 2, 3, 4, 6, 8, 10 mm were used from both devices for a more appropriate comparison. S12 is the sum of the number of 1 mm and 2mm hairs protruding from the yarn body. S3 is the sum of the number of hairs with a length of 3mm and more (3, 4, 6, 8, 10) protruding from the yarn body. After that, the hairiness results given by two different devices in each mm were evaluated statistically in the SPSS packet program. The difference between the devices was computed using the mean results of the five measurements taken on each yarn. The normality of the computed differences between them was analyzed with the One-Sample Kolmogorov Smirnov test. Since the test distribution was found to be normal in all results ($p>0.05$), the differences and correlations between the devices were tested with the paired sample test.

3. RESULTS AND DISCUSSION

The results obtained from two different hairiness devices were shown in Table 2. The difference between the devices for each type of yarn was computed using the mean results in Table 2. The normality test results of these calculated differences were presented in Table 3. As Table III shows, the Kolmogorov-Smirnov test results were not significant at the $p= 0.05$ level. Test distributions were normal in all nine hairiness types.

Table 1. Information on preferred yarns

Yarn Type	Yarn Properties
01	Ecru Ne 36/1 CO/CV
02	Ecru Ne 40/1 CO/CV
03	Ecru Ne 28/2 CO/CV/ELS
04	Ecru Ne 36/2 CO/CV/ELS
05	Ecru Ne 40/2 CO/CV/ELS
06	Ecru Ne 50/2 CO/CV
07	Black Ne 28/1 CO/CV
08	Black Ne 40/1 CO/CV
09	Black Ne 28/2 CO/CV/ELS
10	Black Ne 36/2 CO/CV/ELS
11	Black Ne 40/2 CO/CV/ELS
12	Black Ne 50/2 CO/CV/ELS
13	Black Ne 60/2 CO/CV

Table 2. Hairiness mean results

Yarn Type	Devices	1mm	2mm	3mm	4mm	6mm	8mm	10mm	S1+2	S3
01	G 567	9078	1247	281	95	25	2	1	10325	402
	HL 400	9768	2256	420	158	19	3	0	12024	599
02	G 567	18857	8370	2965	1660	531	82	14	27227	5252
	HL 400	15933	4440	965	414	63	10	2	20373	1452
03	G 567	24937	9885	2902	1357	316	43	5	34822	4622
	HL 400	20335	4263	705	260	28	3	0	24598	996
04	G 567	24151	7526	1935	844	216	24	1	31676	3020
	HL 400	17191	4193	665	295	37	5	1	21383	1001
05	G 567	16743	3938	823	365	40	2	0	20681	1230
	HL 400	9764	1869	256	91	9	1	0	11633	356
06	G 567	15537	3974	1243	675	236	46	5	19511	2205
	HL 400	11569	2757	623	213	27	4	1	14326	867
07	G 567	20997	6233	1561	714	121	18	1	27230	2415
	HL 400	15496	4109	858	352	50	7	1	19604	1267
08	G 567	21815	6051	1531	747	134	10	2	27866	2425
	HL 400	16882	3791	534	224	24	3	0	20673	785
09	G 567	16121	2070	287	81	7	1	1	18191	377
	HL 400	10807	1945	293	90	8	1	0	12752	391
10	G 567	28303	8512	2040	833	121	8	1	36814	3003
	HL 400	21630	4409	527	212	20	2	0	26039	761
11	G 567	16945	3615	756	236	30	3	3	20560	1028
	HL 400	10484	2124	367	119	12	1	0	12608	498
12	G 567	11523	2079	405	135	22	4	0	13601	566
	HL 400	10190	1744	270	77	7	1	0	11934	354
13	G 567	15353	4570	1321	695	244	32	3	19923	2294
	HL 400	13407	2896	372	157	16	2	0	16303	547

Table 3. Normality test results

Hairiness	Asymp. Sig. (2-tailed)
1 mm	0,922
2 mm	0,908
3 mm	0,988
4 mm	0,828
6 mm	0,796
8 mm	0,420
10 mm	0,494
S12	0,906
S3	0,996

The results of the paired sample test were given in Table 4 and Table 5. When the p values indicating the significance levels of the correlation coefficients in Table 4 were examined, it was seen that the correlation was statistically significant in all mm types. As shown in Table 5, significant differences were observed between the two instrument hairiness results in all mm types ($p<0,05$). Despite this difference, a strong positive correlation was found in all hairiness except 10 mm in Table 4. There was also positive correlation (r=0,704) in 10 mm.

The differences and percentages of the results of hairiness in different mm for each type of yarn were presented in Figure 1-9.

Table 4. Paired Sample Correlation results

Hairiness	N	Correlation Coefficient (r)	Significance level (p)
1 mm	13	0,911	0,000
2 mm	13	0,922	0,000
3 mm	13	0,807	0,001
4 mm	13	0,837	0,000
6 mm	13	0,764	0,002
8 mm	13	0,758	0,003
10 mm	13	0,704	0,007
S12	13	0,938	0,000
S3	13	0,825	0,001

Table 5. Paired sample test results

Hairiness	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
1 mm	4377,47	2392,46	663,55	2931,72	5823,22	6,597	12	0,000
2 mm	2098,11	1810,25	502,07	1004,19	3192,04	4,179	12	0,001
3 mm	861,41	728,49	202,05	421,19	1301,63	4,263	12	0,001
4 mm	444,63	395,83	109,78	205,43	683,82	4,050	12	0,002
6 mm	132,74	138,58	38,43	49,00	216,48	3,454	12	0,005
8 mm	17,97	22,21	6,16	4,55	31,40	2,918	12	0,013
10 mm	2,56	3,45	0,96	0,48	4,65	2,681	12	0,020
S12	6475,59	3636,81	1008,67	4277,88	8673,29	6,420	12	0,000
S3	1459,32	1258,33	348,99	698,91	2219,72	4,181	12	0,001

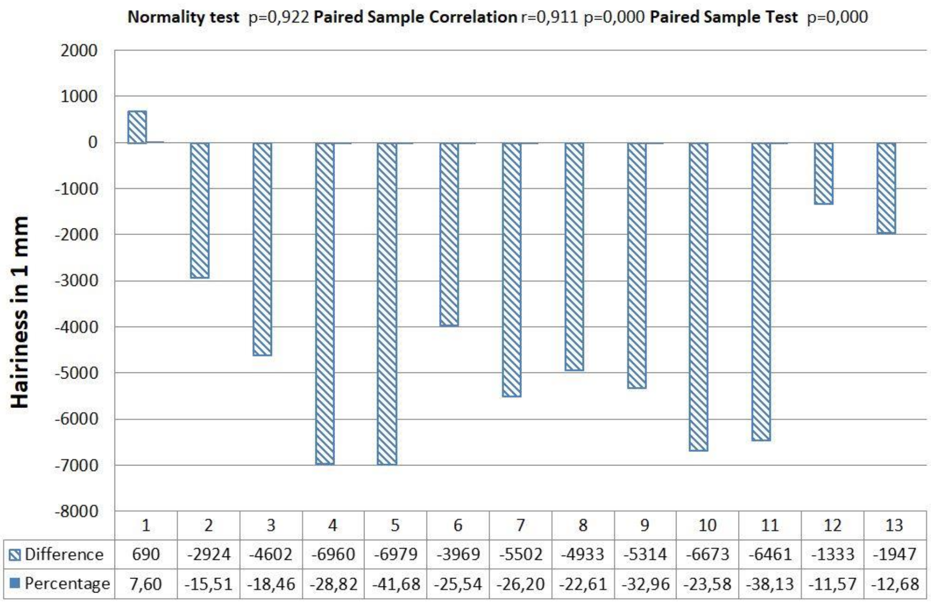
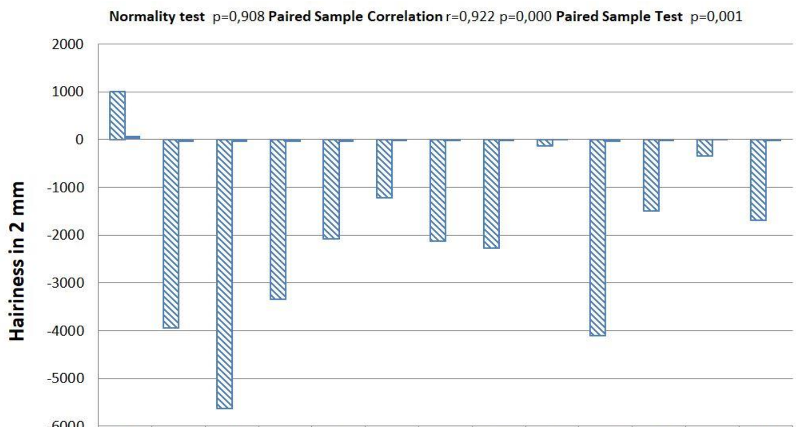


Figure 1. The differences and percentages of the results of hairiness in 1 mm

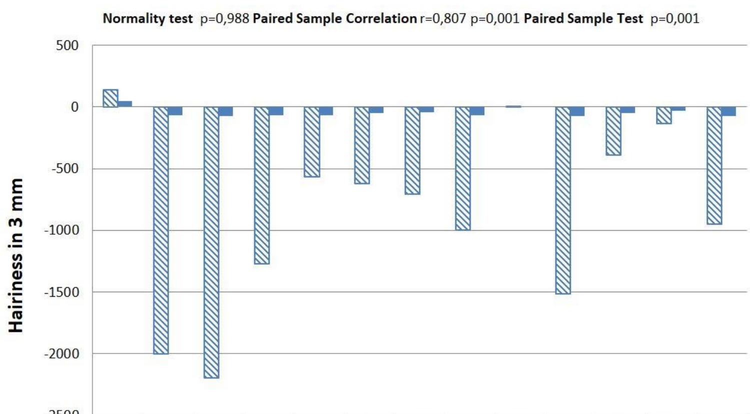
In Figure 1, all yarns except yarn 1 in HL400 showed lower values than G567. The highest difference was seen in yarn 5 with -6979. The highest percentage change was in yarn 5 with a value of -41,68%. The lowest difference (690) and percentage change (7,6%) were found in yarn 1. It was seen from the 1 mm results in Table 5 that there is a significant difference between the two devices (p=0,000). In yarns 1-2 (Ecru CO/CV) with the same structure and different yarn counts, the hairiness difference as percentage between the devices increased as the yarn count increased. Similarly, in yarns numbered 3-4-5 (Ecru CO/CV/ELS), the hairiness difference as percentage between devices increased as the yarn count increased. The difference was decreased in yarns 7-8 (Black CO/CV) and no trend was observed in yarns numbered 9-10-11-12 (Black CO/CV/ELS). The results also showed differences when the yarns with the same structure and same yarn count were dyed. The percentage difference between the devices increased in the dyed condition in yarns 2-8 (40/1 CO/CV) and yarns 3-9 (28/2 CO/CV/ELS). But, the percentage difference showed a decrease in 4-10 yarns (36/2 CO/CV/ELS) and 5-11 yarns (40/2 CO/CV/ELS). Taken as a whole, it was seen from the 1 mm results in Table 4 there was a strong positive correlation between the results obtained from the devices (r=0,911).

From the 2 mm results in Figure 2, lower values were measured in HL400 for all yarns except yarn 1 similar to 1mm. The highest difference at 2 mm was found in yarn 3 with -5622. The highest percentage change was in yarn 1 with a value of 80,87%. The lowest difference (-125,3) and percentage change (-6,05%) were found in yarn 9. When the 2 mm results were examined, it was observed that there was a significant difference between the devices (p=0,001). As the yarn count increased, the hairiness difference as percentage between the devices decreased in yarns 1-2 (Ecru CO/CV) and increased in yarns 7-8 (Black CO/CV). No trend was seen in yarns 3-4-5 (Ecru CO/CV/ELS) and yarns numbered 9-10-11-12 (Black CO/CV/ELS). While the percentage difference between the devices decreased in the dyed condition in yarns 2-8 (40/1 CO/CV), 3-9 (28/2 CO/CV/ELS) and 5-11 (40/2 CO/CV/ELS), it increased in yarns numbered 4-10 (36/2 CO/CV/ELS). Despite these significant differences between the two devices, a strong positive correlation was determined between the devices (r=0,922).



	1	2	3	4	5	6	7	8	9	10	11	12	13
Difference	1008,5	-3930	-5622	-3333	-2069	-1217	-2125	-2261	-125,3	-4103	-1491	-334,7	-1674
Percentage	80,87	-46,96	-56,87	-44,29	-52,54	-30,62	-34,08	-37,36	-6,05	-48,20	-41,25	-16,10	-36,63

Figure 2. The differences and percentages of the results of hairiness in 2 mm



	1	2	3	4	5	6	7	8	9	10	11	12	13
Difference	139	-2000	-2197	-1271	-567	-620,3	-703,8	-997,8	5,5	-1513	-389,3	-135,5	-949,2
Percentage	49,55	-67,45	-75,70	-65,66	-68,89	-49,89	-45,08	-65,16	1,92	-74,16	-51,48	-33,46	-71,87

Figure 3. The differences and percentages of the results of hairiness in 3 mm

It was seen from 3 mm results in Figure 3 that HL 400 had a higher value in yarn 9 in addition to yarn 1 according to G567, differently from 1mm and 2mm results. The highest measurement difference and percentage change between devices at 3mm was in yarn 3, similar to 2 mm. The lowest difference (5,5) and percentage change (1,92%) were found in yarn 9, similar to 2 mm. Significant differences were determined between the two devices (p=0,001) as can be seen from Table 5.In yarns 1-2 (Ecru CO/CV) and 7-8 (Black CO/CV) with the same structure and different yarn counts, the hairiness difference as percentage between the devices increased as the yarn count increased. In yarns numbered 3-4-5 (Ecru CO/CV/ELS) and 9-10-11-12 (Black CO/CV/ELS), the percentage difference between devices showed no trend as the yarn count increased. In the dyed condition, different results were found the yarns having the same structure and same yarn count. The percentage change between the devices decreased in yarns 2-8 (40/1 CO/CV), yarns 3-9 (28/2 CO/CV/ELS) and 5-11 yarns (40/2 CO/CV/ELS). Differently from others, an increase was determined in 4-10 yarns (36/2 CO/CV/ELS). There were lower values in 3mm results compared to 1mm and 2mm but still a strong positive correlation was found in Table 4 between the devices (r=0,807).

Figure 4 shows that lower hairiness was observed in HL400 in all yarns except yarns 1 and 9, similar to the 3 mm results. The highest measurement difference and percentage change between devices at 4mm was in yarn 3, similar to 2 and 3 mm results. The lowest difference (8,17) and percentage change (10,05%) were found in yarn 9, similar to 2 and 3 mm results. The hairiness difference as percentage in the 4 mm results between the devices showed a same trend as the 3 mm results in yarns with the same structure and different yarn counts (1-2, 3-4-5, 7-8 and 9-10-11-12). Also, in the dyed condition, there were also same trends the yarns having the same structure and yarn count (2-8, 3-9, 4-10 and 5-11) between the 3 mm and 4 mm results. Significant differences were found between the two devices (p=0,000) in general terms. In addition to this, there was a strong positive correlation between the devices (r=0,837). The 3mm and the 4mm results were largely similar. Furthermore, higher correlation was found at 4mm compared to 3mm as can be seen from Table 4.

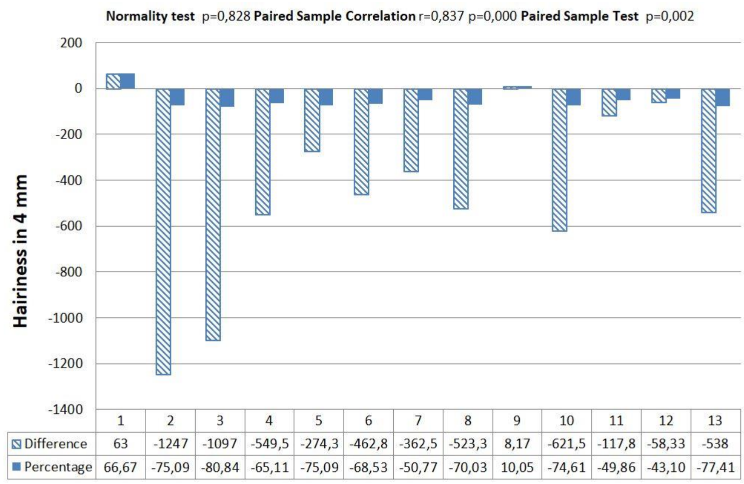


Figure 4. The differences and percentages of the results of hairiness in 4 mm

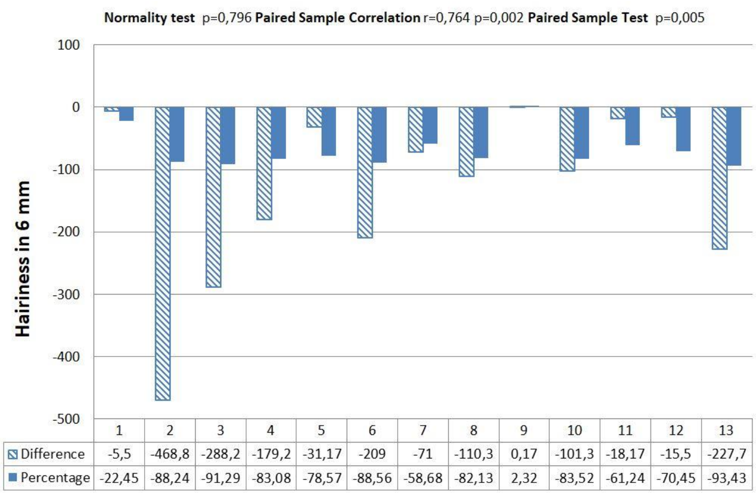
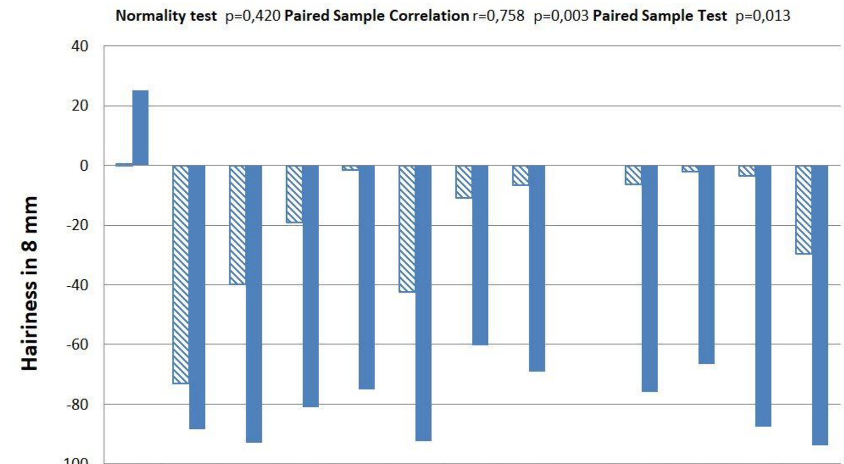


Figure 5. The differences and percentages of the results of hairiness in 6 mm

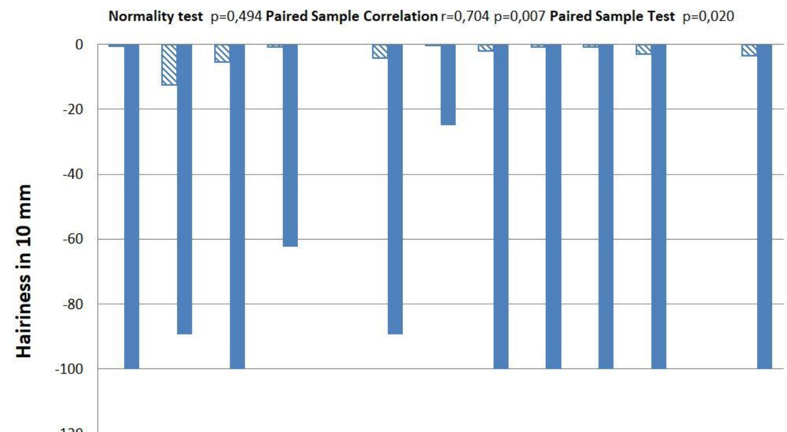
According to Table 5, there was significant difference between the two devices (p=0,005). On the other hand, a strong positive correlation was observed between the devices (r=0,764) from Table 4. However, a lower correlation was obtained than the results at 1, 2, 3 and 4mm. The hairiness difference as percentage in the 6 mm results between the devices showed a same trend as the 3 and 4 mm results in yarns with the same structure and different yarn counts (1-2, 7-8 and 9-10-11-12). In yarns numbered 3-4-5 (Ecru CO/CV/ELS), the percentage difference between devices showed a decrease as the yarn count increased differently from the 3 and 4 mm results. Also, in the dyed condition, there were also same trends the yarns having the same structure and same yarn count (2-8, 3-9, 4-10 and 5-11) such as in 3 mm and 4 mm results. Lower hairiness was observed in HL400 in all yarns except yarn 9 in 6 mm results. The highest measurement difference between devices at 6mm (-468,8) was in yarn 2. The highest percentage change (-93,43) among the devices was in yarn 13. The lowest difference (0,17) and percentage change (2,32%) was found in yarn 9.

According to 8 mm results in Figure 6, slightly higher hairiness was observed in yarn 1 and lower hairiness in other yarns in HL400. No change was found in yarn 9. The highest measurement difference (-72,83) between devices at 8mm was measured in yarn 2. The highest percentage change (-93,68) among the devices was in yarn 13. The hairiness difference as percentage in the 8 mm results between the devices showed a same trend as the 6 mm results in yarns with the same structure and different yarn counts (1-2, 3-4-5, 7-8 and 9-10-11-12). Furthermore, in the dyed condition, same trends observed the yarns having the same structure and same yarn count (2-8, 3-9 and 5-11) such as in 6 mm results. In yarns numbered 4-10 (36/2 CO/CV/ELS), the percentage change between devices showed a decrease differently from the 6 mm results. Significant differences were found between the two devices (p=0,003). However, there is also a strong positive correlation between devices (r=0,758). A lower correlation was obtained than results at 1, 2, 3, 4, and 6mm.



	1	2	3	4	5	6	7	8	9	10	11	12	13
Difference	0,5	-72,83	-39,67	-19,17	-1,5	-42,17	-10,67	-6,67	0	-6,33	-2	-3,5	-29,67
Percentage	25,00	-88,46	-92,97	-80,99	-75,00	-92,34	-60,38	-68,98	0,00	-75,99	-66,67	-87,50	-93,68

Figure 6. The differences and percentages of the results of hairiness in 8 mm

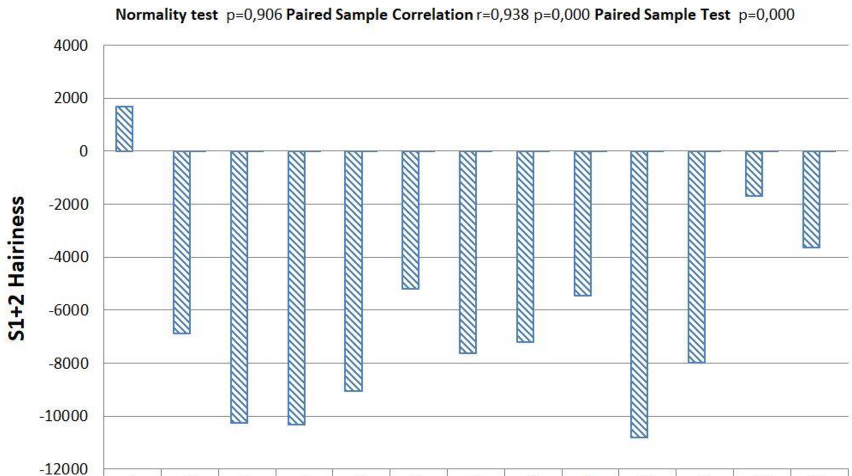


	1	2	3	4	5	6	7	8	9	10	11	12	13
Difference	-0,5	-12,5	-5,33	-0,83	0	-4,17	-0,33	-2	-0,67	-0,67	-3	0	-3,33
Percentage	-100,0	-89,29	-100,0	-62,41	0,00	-89,29	-24,81	-100,0	-100,0	-100,0	-100,0	0,00	-100,0

Figure 7. The differences and percentages of the results of hairiness in 10 mm

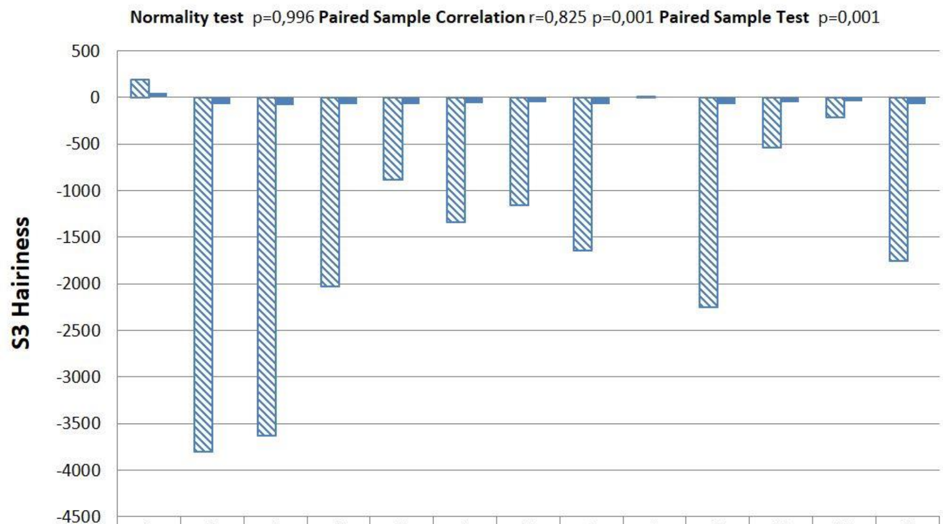
As illustrated in Figure 7, there was no increase in hairiness in the HL400 compared to Zweigle in the 10 mm results. There was no change in yarns 5 and 12. In other yarns, lower hairiness was observed in HL400. There was a significant level difference between the results of the two devices (p=0,007). According to Table 2, zero hairs count was found for HL400 in nine yarns in 10 mm results. One hair was measured in three yarns of them and two hairs in one yarn of them. Therefore, a lower correlation was obtained between the two devices than results at 1, 2, 3, 4, 6 and 8 mm. Strong positive correlation was measured between G567 and HL400 (r=0,704).

Figure 8 presents the comparison of S12 hairiness results. S12 is the sum of the number of hairs in 1 and 2mm. It is seen that there were similar results to the 1 and 2 mm results in Figure 1 and Figure 2. Similarly, lower values were measured in HL400 for all yarns except yarn 1 according to G567. The difference between devices was significant level (p=0,000) as can be seen from Table 5. The highest difference was found in yarn 10 (-10775). The highest percentage change was measured in yarn 5 with a value of -43,75%, similar to the 1mm results. The lowest difference (-1668) and percentage change (-12,26%) was found in yarn 12. In the S12 results, there was a same trend with 1 mm results between the devices in the hairiness change as percentage of yarns with the same structure and different yarn counts and the yarns having the same structure and same yarn count. Furthermore, a strong correlation was determined between the devices (r=0,938).



	1	2	3	4	5	6	7	8	9	10	11	12	13
Difference	1698,5	-6855	-10224	-10293	-9048	-5186	-7626	-7194	-5439	-10775	-7953	-1668	-3621
Percentage	16,45	-25,18	-29,36	-32,50	-43,75	-26,58	-28,01	-25,82	-29,90	-29,27	-38,68	-12,26	-18,17

Figure 8. The differences and percentages of the results of hairiness in S1+2



	1	2	3	4	5	6	7	8	9	10	11	12	13
Difference	196,5	-3800	-3627	-2020	-874	-1339	-1148	-1640	13,17	-2243	-530,3	-212,8	-1748
Percentage	48,88	-72,36	-78,46	-66,87	-71,06	-60,70	-47,54	-67,65	3,49	-74,68	-51,57	-37,58	-76,18

Figure 9. The differences and percentages of the results of hairiness in S3

In Figure 9, there were significant differences between the two devices in S3, which is the most important point in yarn hairiness (p=0,001). Higher results were obtained in HL400 for yarns 1 and 9. In other yarns, higher S3 hairiness was found in G567. The highest difference was seen in yarn 12 (-3800). The highest percentage change is -78,46% in yarn 3. The lowest difference (13,17) and percentage change (3,49%) were measured in yarn 9. S3 results were showed same trend with 3 and 4 mm results between the devices in the hairiness change as percentage of yarns with the same structure and different yarn counts and the yarns having the same structure and same yarn count. Strong positive correlation was found between devices (r=0,825). Correlation values between devices for each hairiness values were shown in Figure 10.

It appears from Figure 10 that the correlation between devices tends to decrease as the hair length increases. The highest correlation was seen at 2 mm and the lowest correlation at 10 mm. And, the correlation in S12 was higher than in S3. The correlation level dropped below the strong correlation level of 0.75 in just 10 mm.

When all the results obtained from the devices were evaluated together, it was seen that the 8-fold speed increase in the HL400 device significantly changes the hairiness results. In previous studies on Zweigle's older series, higher hair counts of up to 10 mm in ring and siro yarns and up to 6 mm in open-end yarns were obtained with increases in test speed. In general, it has been emphasized in the literature that there was an increase in the number of hairs due to the increase in test speed in S3 values [2, 3]. In this study, differently from literature, it was seen that there was a decrease in the number of hairs in most of the yarns due to the increase in test speed. The bending of the fiber ends at higher speeds because of air circulation and friction during testing can be shown as the reason for this.
The more surprising result was that the strong correlation was found between G567 and HL400 although the hair number obtained from devices show significant differences. Because the percentage changes between devices in similar yarn structures followed a similar trend in different hair lengths. S12 results were showed same trend with 1mm results and S3 results were showed same trend with 3mm and 4mm results in the hairiness change as percentage between the G567 and HL400 devices for similar yarn structures. This shows that the devices give correlated results according to its operating principle, but the results of two devices operating at different speeds should not be compared with each other on the same test parameters. These differences, which are estimated to occur due to the bending of the fibers as a result of air circulation and friction during the testing, will also affect the results in fibers with different fiber lengths and stiffness. In addition, differences in the spinning system, which will cause different structure and formation in the yarn, will affect the results. These inconsistencies due to the nature of the measurement have also been highlighted in previous studies [5].

4. CONCLUSION

"S3 yarn hairiness" offers disturbing hairiness values that affect the fabric results to manufacturers although it cannot give real yarn hairiness. These devices are the most efficient devices in the determination of yarn hairiness for today. In this research, the results of Zweigle G567 were compared with the Uster Zweigle HL400, in which the measurement speed was increased eight times. It was observed that there were significant differences between the measurement results of two devices. For this reason, the most obvious finding to emerge from this study is that the information of which device the S3 belongs to and at what speed it is tested must be shared in hairiness evaluations in the sector. The results of two devices operating at different speeds should not be compared with each other on the same test parameters (S3). On the other hand, the second major finding was that there was a significant strong correlation between the two devices. This shows that the devices basically continue to exhibit the similar behavior in the measurement.

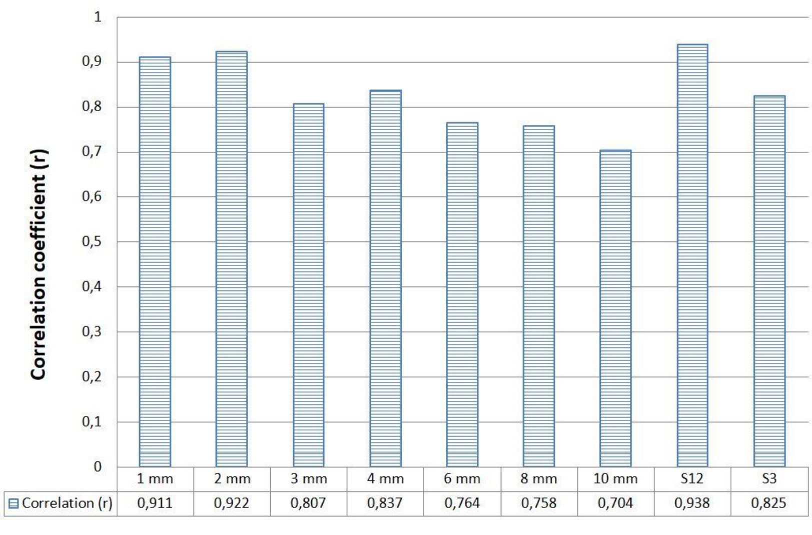


Figure 10. The results of correlation coefficient (r)

Now, S3 hairiness is offered as "hairiness length -Sensor HL" in the Uster Tester 6 as an integrated but optional. It is not sold as a separate device. In the article, two devices, which are widely used in the sector and only on hairiness, are included. Although the measuring principle is the similar in these devices, there are significant differences in the results due to the speed difference. In UT6, the speed increased up to 800 m/min. The aim of the study is to draw attention to the fact that this situation should be known in the sector, and it is wrong to see all of them as the same S3. It can be said that the new versions stand out with the speed advantage it offers. However, it should not be overlooked that differences such as fiber type, fiber composition, yarn count and spinning system will affect the results because of air circulation and friction due to the nature of the measurement. It has been observed once again that these devices offer a general view and that new approaches are needed in the measurement of yarn hairiness.

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