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Analysis of Splicing Method on Bursting Strength of the Knitted Fabrics

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Abstract

The study was carried out as two parts. In the published previous part, the spliced yarn performances were investigated to reveal optimum splicing method in terms of fiber type and yarn count on the basis of splicing methods including air splicing, wet splicing and mechanical (twin) splicing by using pure and blended ring-spun yarns containing cotton, viscose, polyester, modal, and acrylic fibers at different yarn counts of Ne 20, Ne 30 and Ne 40. The study revealed that twin splicer was the best for cotton fiber and acrylic fiber, whereas it was the worst for regenerated cellulosic fibers. All splicer types can be used for polyester fiber, and the best splicer type was air splicer for fine yarns, on the contrary, it was twin splicer for coarse yarns. The current study which is the second part of the study aimes to determine the bursting strength properties of the knitted fabrics on the basis of splice types. For this, the obtained yarns by splicing in different splicer in the previous work were knitted, and then the tests of structural properties and bursting strength were applied for the fabric samples. The results of the study unexpectedly indicate that splice types do not have effect on the bursting strength of the knitted fabrics in spite of the results of the previous study showing splice types clearly affect yarn strength. But, fiber types are effective on the bursting strength as expected. Besides, fabric structural properties do not have effect on the bursting strength because of constant knitting parameters.

Keywords: Bursting strength, Spliced yarn strength, Knitted fabric, Air splice, Wet splice, Twin splice, Fiber types, Yarn count

Örme Kumaşların Patlama Mukavemeti Üzerine Düğümleme Metotlarının Analizi

Öz

Çalışma iki bölüm halinde gerçekleştirildi. Bir önceki bölümde, Ne 20, Ne 30 ve Ne 40 farklı iplik numaralarında pamuk, viskon, polyester, modal ve akrilik elyaf içeren saf ve karışım ring iplikleri kullanılarak havalı splays, ıslak splays ve mekanik (twin) splays gibi splays (düğüm) yöntemlerine göre elyaf cinsi ve iplik numarası açısından optimum splays yöntemini ortaya çıkarmak için splayslı iplik performansları incelendi. Çalışma, mekanik (twin) splays metodunun pamuk lifi ve akrilik elyaf için en iyisi, rejenere selülozik lifler için en kötüsü olduğunu ortaya koydu. Tüm splays metotları poliester elyaf için kullanılabilir ve en iyi splays metodu ince iplikler için hava splays iken aksine kaba iplikler için mekanik (twin) splays idi. Çalışmanın ikinci bölümü olan bu çalışma, örme kumaşların splays metotları bazında patlama mukavemeti özelliklerini belirlemeyi amaçlamaktadır. Bunun için önceki çalışmada farklı düğümleyicilerle splays yapılarak elde edilen iplikler örülmüş, ardından kumaş numunelerine

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yapısal özellikler ve patlama mukavemeti testleri uygulanmıştır. Çalışmanın sonuçları, beklenmedik bir şekilde, splays metotlarının iplik mukavemetini açıkça etkilediğini gösteren önceki çalışmanın sonuçlarına rağmen, splays metotlarının örme kumaşların patlama mukavemetine etkisi olmadığını göstermektedir. Ancak elyaf türleri beklendiği gibi patlama mukavemeti üzerinde etkilidir. Ayrıca, sabit örgü parametreleri nedeniyle kumaş yapısal özelliklerinin patlama mukavemetine etkisi yoktur.

Anahtar Kelimeler: Patlama mukavemeti, Splayslı iplik mukavemeti, Örme kumaş, Havalı splays, Islak splays, Mekanik (twin) spalys, Elyaf cinsi, İplik numarası

1. INTRODUCTION

Splicing is the ultimate method to eliminate yarn faults and problems of knots and piecing. It is a technique of joining two yarn ends by inter-mingling the constituent fibers so that the joint is not significantly different in appearance and mechanical properties with respect to the parent yarn. It is important that the quality of splice in the final yarn is high because low splice performance reduces the yarn breaking strength and elongation decrease, resulting in too many breaks in the machines during fabric production and consequently low yield [1-3].

There are many splicing methods including the pneumatic method, the mechanical method, the pneu-mechanical method and electrostatic method [4]. Among them, pneumatic splicing is the most popular. This basic pneumatic method can be converted into thermo splicer, injection splicer (especially water) and elasto splicer to suit the specific requirements of the material to be spliced.

The applications of the standard splicer are cotton, cotton blends, polyester, viscose, and cotton compact yarns [1]. The use of the injection splicer is recommended for splicing single and plied of vegetable fibers, OE-rotor yarns, and cotton compact yarns. The elasto splicer is especially useful for the splicing of elastic core yarns. The thermo splicer is used for the splicing of wool yarns and blends of them.

Mechanical splicing (twin disc splicing) is a less used method compared to pneumatic splicing [5]. The advantages of this method are the absence of air or any extraneous materials, and the reproducibility of the results.

Many researchers examined the tensile properties of spliced yarn in terms of yarn parameters splicing parameters and splicing methods in their works.

Kaushik et al. [6] indicated that wet splicing gives better property retention than dry splicing; retention of yarn properties in decreasing order was for yarns spun from polyester, polyester-rich blends, viscose, cotton, and wool, respectively; coarse ring spun yarns contribute the most to better-spliced yarn properties.

Cheng et al. [7,8] revealed that the yarn linear density has the most important effect on the strength, bending, abrasion, and appearance properties of spliced yarns in their two different studies.

Nawaz et al. [9] found that the strength properties of the splice region in natural and synthetic blended yarns improve as the synthetic fiber ratio increases.

Taşkın et al. [10] and Hassen et al. [5] proved that the type of splicing mechanism changes the properties of the splice region and wet splicing improves the strength and appearance properties of the splice region.

Gurkan Unal et al. [11] evaluated the retained spliced diameter with regard to splicing parameters and fiber and yarn properties and found that the fiber diameter, short fiber content, yarn count, yarn twist and opening air pressure affect the retained spliced diameter.

On the other hand, it is exactly known that the main factors affecting the bursting strength of the knitted fabrics are yarn strength, yarn type (spinning method), yarn count, fabric density and knitting type [12-18].

This study was carried out as two parts. In the previous part, it was investigated that the spliced yarn performances in terms of three types of splicing methods including air splicing, wet splicing and mechanical splicing which is known as twin disc splicing of pure and blended ring yarns with various fibers and aiming to reveal optimum splicing method in terms of fiber type and yarn count. The study revealed that twin splicer is the best for cotton fiber and acrylic fiber, whereas it is the worst for regenerated cellulosic fibers. All splicer types can be used for polyester fiber, and the best splicer type is air splicer for fine yarns, on the contrary, it is twin splicer for coarse yarns [19].

This current study which is the second part of the study aims to determine the bursting strength properties of the knitted fabrics on the basis of splicing types and additionally raw material and yarn count. It is expected that the study will contribute to the literature because splicing types including air splicing, wet splicing, and twin splicing is firstly researched in terms of bursting strength of the knitted fabrics.

2. MATERIAL AND METHOD

For this study, by using the raw materials were cotton (CO), viscose (CV), polyester (PES), modal (CMD) and acrylic (PAC), twenty seven pure and blended ring-spun yarns were produced at different yarn count including Ne 20, Ne 30 and Ne 40, and at different blend ratios which were 100%, 80-20%, 65-35%, and 50-50%. Modal and acrylic yarns with blend ratios of 80/20% and 65/35% could not be produced because of the textile mill could be only produced different yarn counts depending on the yarn blends that existed in the production process at that time due to the fact that the yarn samples production was very difficult and labor-intensive. The yarn properties were given in Table 1.

Table 1. Yarn properties [19]

Yarn count	Yarn type	CVm %	Thin -50%/km	Thick +50%/km	Neps +200%/km	Hairiness H	Elongation %	Tenacity cN/tex
Ne 20	100% CO	9.6	0	2.5	4.5	4.52	6.85	17.34
	100% CV	9.45	0	4	5	3.85	14.38	18.93
	100% PES	9.52	0	2	2	4.86	12.53	30.23
	80/20% CO/PES	11.41	0	10	5	5.79	6.4	16.97
	65/35% CO/PES	10.6	0	3.5	2	5.75	7.72	18.42
	50/50% CO/PES	10.32	0	1.5	0	5.32	9.5	20.00
	50/50% CO/CMD	9.76	0	2	3	5.32	7.49	17.76
	50/50% CO/PAC	13.18	0	57	34	8.29	5.64	11.92
Ne 30	100% CO	11.6	0	7	20	4.21	5.29	17.73
	100% CV	11.34	10	9	21	3.3	13.45	18.05
	100% PES	11.94	3	6	7	4.09	10.66	28.39
	80/20% CO/PES	13.06	0.5	38.5	27.5	4.84	6.75	17.18
	65/35% CO/PES	12.72	0.5	33	21.5	5.24	6.62	16.55
	50/50% CO/PES	12.43	1.5	21	18	4.6	9.03	20.03
	50/50% CO/CMD	11.28	0	6	9.5	4.85	6.55	17.05
	50/50% CO/PAC	15.72	12	242	158	7.98	4.25	10.09
Ne 40	100% CO	12.44	0	17.5	28.5	3.73	5.71	17.02
	100% CV	12.80	5	16	31	2.92	12.08	17.30
	100% PES	13.53	15	124.7	24	3.48	9.94	26.65
	80/20% CO/PES	14.81	20.5	94.5	80.5	4.7	4.84	15.06
	65/35% CO/PES	14.52	9.5	91.5	71	4.74	6.16	15.09
	50/50% CO/PES	13.94	7	63.5	46.5	4.18	6.68	18.46
	50/50% CO/CMD	12.24	0	24.5	29	3.49	6.92	17.56
	50/50% CO/PAC	14.84	6	102.5	196.5	6.82	5.46	13.02

Standard yarn tests including unevenness, imperfection, hairiness and tensile were performed to the obtained yarns after yarn manufacturing by relevant standards.

Before splicing the breaking strength and elongation of yarns were measured in Mesdan-Lab Splice Scanner-3 test device in accordance with TS 245 EN ISO 2062 standard. After this, the splicing process was carried out for all yarns on Savio Polar IDLS winding machine having separate units of air splicer and wet splicer, and twin disc splicer for a certain period of time by using the same unit each time. After each splicing, the breaking strength and elongation values of spliced yarns were measured with the same device. The results were shown in Table 2 before and after splicing.

Table 2. Strength and elongation before and after splicing [19]

Yarn type	Yarn count Ne	Strength (kg)				Elongation (%)			
		Yarn***	Air	Wet	Twin	Yarn***	Air	Wet	Twin
100% CO	20	510	339	358	457	4.90	2.92	2.84	3.68
	30	301	233	251	300	3.31	2.30	2.41	2.79
	40	238	179	206	206	2.80	2.14	2.64	2.45
100% CV	20	519	476	409	449	13.06	11.98	10.6	10.37
	30	322	310	249	234	12.26	11.68	8.63	6.87
	40	331	313	172	174	10.37	10.02	7.62	6.02
100% PES	20	880	783	699	738	11.04	10.10	8.39	9.40
	30	552	446	483	479	9.09	7.76	7.98	8.41
	40	422	383	368	361	9.49	8.34	7.97	7.63
80-20% CO/PES	20	500	330	367	479	5.35	3.56	4.24	5.53
	30	320	251	319	314	4.62	3.41	4.68	4.11
	40	232	196	222	221	4.30	3.64	4.26	3.44
65-35% CO/PES	20	493	371	459	514	6.60	4.70	6.19	6.38
	30	314	271	297	323	5.15	3.91	4.78	4.58
	40	231	181	190	224	5.14	3.94	4.44	4.92
50-50% CO/PES	20	604	485	508	623	9.19	7.54	7.68	8.68
	30	376	323	340	371	7.48	6.18	6.86	6.90
	40	263	231	250	257	5.63	5.10	5.92	5.07
50-50% CO/CMD	20	470	368	418	456	6.50	4.06	4.92	4.94
	30	312	276	241	265	5.22	4.43	3.48	3.53
	40	241	191	204	207	4.06	2.94	3.36	3.01
50-50% CO/PAC	20	304	258	289	321	3.80	3.44	4.29	4.43
	30	208	172	169	190	5.02	3.42	3.57	3.42
	40	172	139	133	166	3.2	2.52	2.44	2.84

*** Before splicing

All yarn samples were knitted in Faycon CKM 01-S laboratory type circular knitting machine having E18 gauge at the constant machine parameters. After knitting, the structural properties including stitch density (wales/cm x course/cm), mass, and thickness of the knitted fabrics were determined via relevant standards which are TS EN 14971, TSE EN 12127, TS 7127 EN ISO 5084 [20-22] and lastly bursting strength tests were performed for these fabrics in James Heal Truburst test device according to TS EN ISO 13938-2 standard [23]. The test results of the knitted fabrics are given in Table 3. The structural properties of the fabric samples showed slight differences depending on the type of fiber and yarn in the fabrics, though the process parameters in knitting were kept constant. However, it is thought that these differences are far from affecting the results of bursting strength to a large extent.

Table 3. Fabric structural properties [19]

Raw Material	Yarn count Ne	Air: Stitch density/cm^2	Air: Mass g/cm^2	Air: Thickness mm	Wet: Stitch density/cm^2	Wet: Mass g/cm^2	Wet: Thickness mm	Twin: Stitch density/cm^2	Twin: Mass g/cm^2	Twin: Thickness mm
100% CO	20	190.20	184.50	0.64	195.75	186.30	0.65	189.00	182.77	0.59
	30	223.06	141.30	0.58	225.00	144.30	0.61	204.25	140.30	0.63
	40	237.33	110.90	0.59	207.00	108.60	0.53	224.75	111.13	0.57
100% CV	20	182.81	168.75	0.46	190.00	172.20	0.47	200.00	167.10	0.48
	30	154.67	99.40	0.37	166.75	106.15	0.39	166.00	99.13	0.35
	40	154.19	70.73	0.32	149.11	75.03	0.35	152.89	76.80	0.33
100% PES	20	206.25	187.35	0.44	215.00	206.90	0.47	225.78	202.17	0.47
	30	183.22	118.23	0.35	198.61	125.83	0.38	219.72	126.87	0.44
	40	208.25	113.90	0.38	201.00	105.10	0.38	188.00	115.90	0.36
80-20% CO/PES	20	201.00	203.83	0.66	196.00	196.87	0.64	216.92	199.03	0.63
	30	242.00	150.40	0.65	214.50	145.67	0.63	228.56	149.53	0.65
	40	207.60	98.75	0.57	208.25	101.40	0.59	206.25	94.10	0.56
65-35% CO/PES	20	195.50	198.80	0.79	184.00	198.50	0.85	200.50	199.60	0.72
	30	209.00	146.80	0.63	195.50	134.23	0.59	207.00	140.75	0.59
	40	210.00	103.35	0.48	222.00	104.95	0.50	218.75	106.25	0.51
50-50% CO/PES	20	203.33	204.03	0.61	206.50	202.87	0.62	181.67	191.97	0.57
	30	176.25	121.80	0.61	175.38	116.20	0.61	163.19	120.75	0.59
	40	219.78	105.07	0.51	217.00	105.33	0.47	201.50	103.90	0.46
50-50% CO/CMD	20	172.50	191.00	0.55	178.06	190.63	0.58	180, 44	192.50	0.57
	30	199.50	136.30	0.56	195.50	135.50	0.54	198.00	129.30	0.55
	40	172.00	94.20	0.44	191.67	90.60	0.43	189.11	93.67	0.44
50-50% CO/PAC	20	116.38	144.45	0.61	118.75	152.00	0.65	112.50	151.27	0.62
	30	126.00	90.40	0.54	132.00	101.70	0.57	132.00	101.70	0.56
	40	166.36	83.10	0.44	154.88	82.05	0.43	164.83	82.13	0.45

Lastly, by using the statistical software package SPSS 25, analyses of variance (ANOVA) were applied in order to determine the relationships between the independent variables which are yarn type, fiber types, splice type, yarn strength and spliced yarn strength the dependent variable which is bursting strength at 95% confidence interval. The analyses were performed separately for each yarn number.

3. RESULTS AND DISCUSSION

The results of bursting strength were examined separately by yarn count. The graphics given in the following figures were drawn as dual axes. The values of bursting strength which are the first axis were shown in the columns on the basis of splice type and yarn type, whereas the values of the spliced yarn strength which are the second axis were shown in the lines to see the effect of the spliced yarn strength on the bursting strength in the fabric samples. Likewise, the statistical results were displayed in the following tables on the basis of yarn count.

It is seen that the bursting strength results in Figure 1 for Ne 20. According to this figure, the bursting strength values for twin splice are the highest in the yarns including 100% CO, 100% PES, 80-20% CO/PES, and 50-50% CO/PAC, while the values for air splice are the lowest except the yarn of 50-50% CO/PAC, because the values for air splice and wet splice are very close in the yarn of 50-50% CO/PAC. The values for all splice types are very much close and there is slightly declining trend from air splice to twin splice in the yarns of 65-35% CO/PES, 50-50% CO/PES and 50-50% CO/CMD. On the contrary, the value for air splice is the highest whereas it for wet splice is the lowest in the yarn of 100% CV.

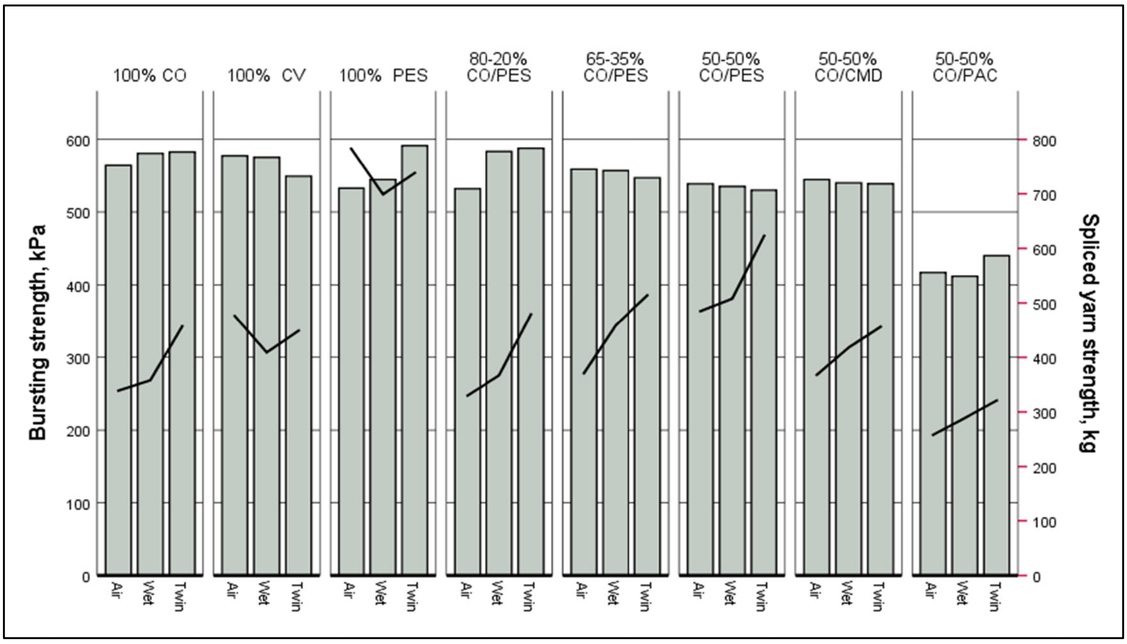

Figure 1. Bursting strength for the fabrics having Ne 20 yarns

Based on the values of the spliced yarn strength it can be said that the results of the bursting strength are surprising because the effect of splice type, which is clearly seen in the yarns, is not clear for bursting strength. Insomuch that apparent tendency to increase for all yarns except 100% CV and 100% PES disappear, and almost closer results are obtained. Moreover, the opposite trends are seen for the yarns of 100% CV and 100% PES.

Given ANOVA results in Table 4 also support the obtained findings that yarn type or the some of the used fibers, especially CO and PAC, have significant effect whereas splice types are not effective on the bursting strength. On the other hand, the same ANOVA values exhibit that the values of yarn strength change according to yarn type, and so these factors can be accepted as same in terms of bursting strength. The other factors which are spliced yarn strength and fabric structural properties as expected have not significant effect on bursting strength.

Table 4. ANOVA results for bursting strength

Factors	Ne 20		Ne 30		Ne 40	
	F	Sig.	F	Sig.	F	Sig.
Yarn type	**22.552**	**.000**	**170.909**	**.000**	**91.209**	**.000**
Splice type	.126	.883	.001	.999	.003	.997
CO	**3.636**	**.023**	.755	.567	.376	.823
CV	1.050	.317	3.652	.069	**5.639**	**.027**
PES	.556	.697	**3.922**	**.017**	**17.313**	**.000**
CMD	.002	.968	.279	.603	.129	.723
PAC	**112.414**	**.000**	**43.943**	**.000**	**6.281**	**.020**
Yarn strength	**22.552**	**.000**	**170.909**	**.000**	**91.209**	**.000**
Spliced yarn strength	-	-	**47.171**	**.021**	96.006	.080
Stitch density	-	-	**30.412**	**.032**	.284	.926
Mass	-	-	33.184	.136	-	-
Thickness	.455	.909	1.273	.356	4.052	.034

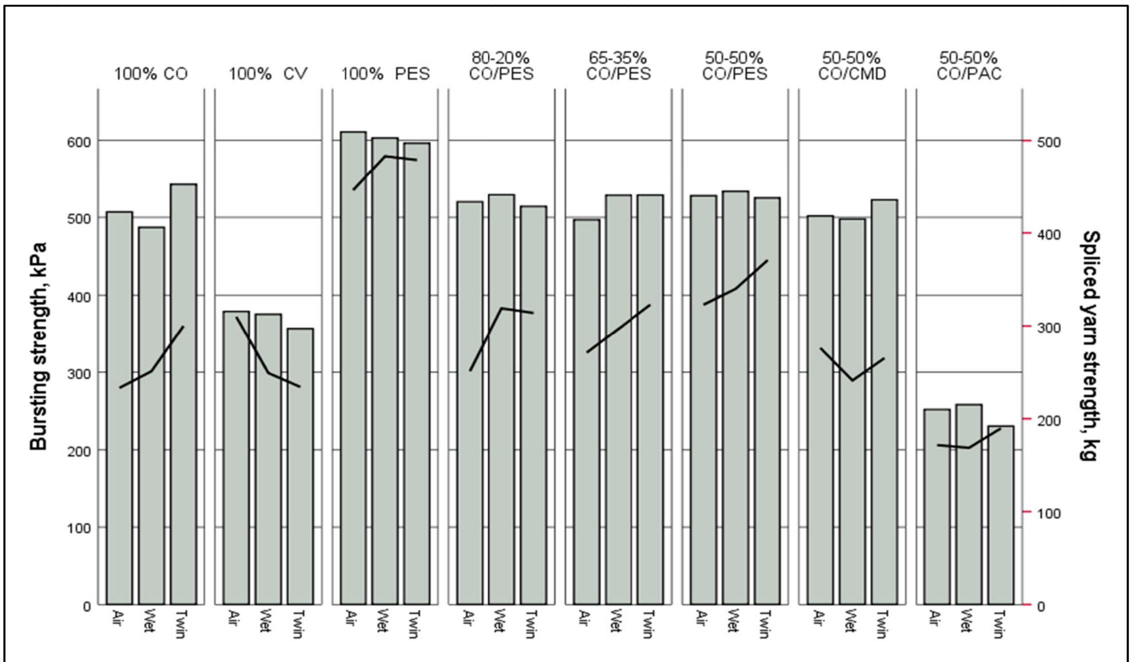

Figure 2. Bursting strength for the fabrics having Ne 30 yarns

According to Figure 2 for twin splice, the bursting strength values in the yarns of 100% CO and 50-50% CO/CMD are the highest while they are the lowest in the yarns of 100% CV and 50-50% CO/PAC. In most of the yarn types for air splice and wet splice, the bursting strength values are close to each other. For only the yarn of 65-35% CO/PES, the bursting strength value for air splice is clearly lower than the others. In particular, for all splice types the bursting strength values are very close in the yarns of 100% PES, 80-20% CO/PES, and 50-50% CO/PES.

When the bursting strength and spliced yarn strength are evaluated together, the differences in the values of bursting strength are much less than those of in the values of spliced yarn strength although the tendency to increase or decrease in values is similar in the yarns of 100% CV, 80-20% CO/PES, 65-35% CO/PES, and 50-50% CO/CMD. Conversely, in the other yarns the tendencies do not match and it is seen that there are opposite tendencies in the yarns including 100% PES, 50-50% CO/PES and 50-50% CO/PAC.

ANOVA results show that yarn type–yarn strength, PAC and PES, spliced yarn strength, and stitch density are effective whereas splice types, the other fibers, and the other fabric structural properties are not effective on the bursting strength. Furthermore, it is noticed that the significant effects of spliced yarn strength and stitch density are seen for only Ne 30.

From Figure 3, it is observed that the bursting strength values for air splice are the highest in the yarns of 100% CV, 100% PES, and 65-35% CO/PES, the values are the highest for wet splice in the yarns of 100% CO, and 50-50% CO/CMD, and these values are the highest for twin splice in the yarns of 80-20% CO/PES, and 50-50% CO/PES and 50-50% CO/PAC.

If the results of bursting strength are investigated in terms of spliced yarn strength, it is possible to say that the trend in the spliced yarn strength and the trend in the bursting strength are partially parallel for the yarns of 100% CV, 100% PES, 80-20% CO/PES, 50-50% CO/PES and 50-50% CO/PAC. But, it cannot be said that the trends are parallel for the yarns of 100% CO, 65-35% CO/PES and 50-50% CO/CMD. There is even the opposite trend for 65-35% CO/PES. In addition to these, the differences in the values of bursting strength of splice types are much less in comparison with the values of spliced yarn strength as become in the fabrics having Ne 20 and Ne 30.

According to ANOVA results, there is significant effect of yarn type–yarn strength, CV, PES, and PAC, whereas spliced yarn strength and fabric structural properties have not effect on the bursting strength.

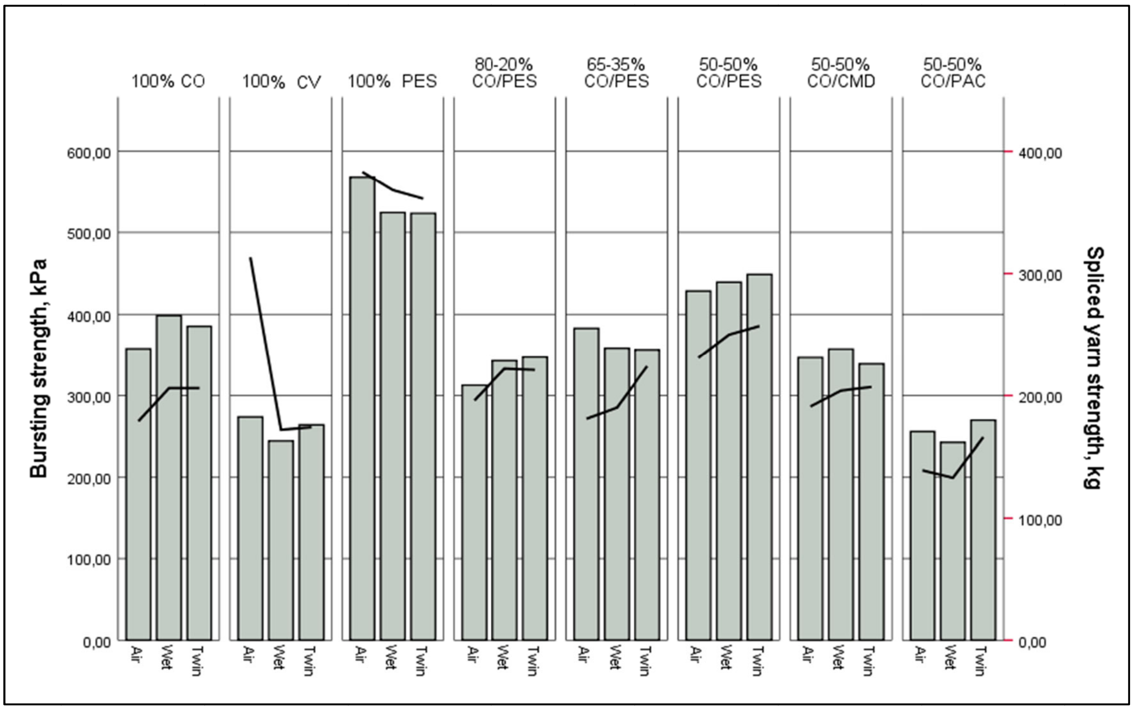

Figure 3. Bursting strength for the fabrics having Ne 40 yarns

4. CONCLUSION

In the previous study, it was investigated that spliced yarn performances in terms of splice types including air splicing, wet splicing, and mechanical (twin) to determine optimum splicing method in terms of fiber type and yarn count. The results of that study proved that yarn count and fiber type could play a decisive role for splicer selection that the optimum splicer type is twin splicer for the yarns containing cotton and acrylic fibers, it is air splicer for especially for fine yarns containing the regenerated cellulosic fibers, and all splicer types are appropriate for polyester fiber. Furthermore, it is determined that air splicer is suitable for fine yarns, whereas twin splicer is suitable for coarse, and splice type clearly affect the properties such as hairiness, diameter, wieving of splice region in the yarns.

The current study which is the second part of the main study aimes revealing the effect of splicing method on bursting strength of the knitted fabrics. The amazing results are obtained with this study. In more detail, the findings unexpectedly indicate that splice types have not effect on the bursting strength of the knitted fabrics in spite of the results of the previous study showing splice types clearly affect yarn strength. But, fiber types are effective on the bursting as expected. Besides, fabric structural properties do not have effect on the bursting strength because of constant knitting parameters.

Although splice types do not affect the bursting strength of the knitted fabrics as expected, it is thought that splice types can affect the other properties such as pilling and abrasion resistance in the fabrics since splice types are effective on the yarn structural properties including hairiness, diameter etc. So, further studies can be performed to demonstrate the effect of splice types on pilling or abrasion resistance, elasticity, permeability etc in the knitted fabrics.

5. ACKNOWLEDGEMENT

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