(REFEREED RESEARCH)

THE EFFECTS OF VACUUM STEAMING PROCESS PARAMETERS ON TENACITY PROPERTIES OF COTTON AND VISCOSE YARNS

VAKUMLU BUHARLAMA İŞLEM PARAMETRELERİNİN PAMUK VE VİSKON İPLİKLERİNİN MUKAVEMET ÖZELLİKLERİNE ETKİLERİ

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ABSTRACT

In this study, the effects of vacuum steaming process parameters (temperature and duration) on tenacity properties of 100 % cotton and 100 % viscose yarns were studied. For this purpose, the yarns with different twisting coefficients and numbers were twisted and exposed to vacuum steaming at different temperatures and for durations appropriate to their raw material properties. Tenacity properties of the yarns were measured before and after vacuum steaming. The results obtained were assessed by means of SPSS statistical analysis program. Variation analysis and SNK test were carried out at 5% (0.05) level of significance. As a result of this study, it can be inferred that vacuum steaming temperature has significant effect on tenacity properties of 100 % cotton and 100 % viscose yarns but vacuum steaming duration has been found to be statistically insignificant on tenacity properties of cotton yarns, and viscose yarns.

Key Words: Vacuum steaming, Temperature, Tenacity, Yarn, Cotton, Viscose, Twisting.

ÖZET

Bu çalışmada vakumlu buharlama işlem parametrelerinin (sıcaklık ve süre) % 100 pamuk ve % 100 viskon ipliklerinin mukavemet özelliklerine etkileri incelenmiştir. Bu amaçla farklı numarada ve farklı büküm katsayısında bükülen ipliklere hammadde özelliklerine uygun olarak farklı sıcaklık ve sürelerde vakumlu buharlama işlemleri yapılmıştır. İpliklerin mukavemet özellikleri vakumlu buharlama işlemleri öncesinde ve sonrasında ölçülmüş ve elde edilen sonuçlar SPSS istatistik programında % 5 anlamlılık seviyesinde gerçekleştirilen varyans analizi ve SNK testleri ile değerlendirilmiştir. Yapılan bu çalışma sonucunda vakumlu buharlama sıcaklığının % 100 pamuk ve % 100 viskon ipliklerinin mukavemet özelliklerine etkisinin istatistiksel olarak önemli olduğu, vakumlu buharlama süresinin ise istatistiksel olarak önemli olmadığı bulunmuştur.

Anahtar Kelimeler: Vakumlu buharlama, Sıcaklık, Mukavemet, İplik, Pamuk, Viskon, Büküm.

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1. INTRODUCTION

Cotton and viscose fibres are hygroscopic; that is, they have the ability to absorb moisture from the environment where they are kept (1). Therefore, as the relative humidity of the environment increases, the amount of moisture absorbed by these fibres rises, which results in some changes in the physical properties of the yarns made of these fibres. On the other hand, moisture levels of yarns decrease due to the modern machinery with high production speed. For example, cotton yarns contain 4-6 % moisture when they have been produced on a spinning machine (2). The decreases in moisture levels of the yarns are likely to bring about some difficulties in the following processing steps; also, yarns with lower moisture content than the standard value result in monetary loss in sale. Therefore; the moisture contents of yarns must be increased to the standard levels so that their physical properties can be improved (3-6).

In textile industry, applications such as conditioning, heat setting, relaxing, and shrinking are carried out in order to overcome all these problems. The process carried out with the aim to increase moisture contents of the yarns is called conditioning. Up to date, conditioning process has been performed via various methods such as conditioning in conditioning rooms, circulation method of conditioning and radio frequency conditioning; however, today, it is generally carried out on steaming machines which provide saturated moisture in a vacuum environment at a low temperature. In addition, some other processes such as heat setting and relaxation are performed on these steaming machines (7-9).

Heat setting and relaxation are also vacuum steaming processes which are carried out at high temperatures and they increase the resistance of high twist yarns, multiply yarns and synthetic filament yarns to untwisting and snarling problems which occur at their unwinding from packages (10, 11). Therefore, all these processes are called vacuum steaming and in this study the effects of vacuum steaming on the properties of 100 % cotton and 100 % viscose yarns have been examined (4).

There are two different types of vacuum steaming carried out with saturated steam in a vacuum environment: Direct and indirect system. In the direct system, the steam obtained in a separate tank is directly left into the steaming chamber. In the indirect system, there is only one steaming chamber and the steam is obtained by heating the water bath with heaters at the bottom of the chamber. The temperature of the environment can be adjusted to the desired level by means of electrical heaters (3, 4, 6, 8, 9).

During our literature survey we found that only a few studies were performed about the effects of vacuum steaming on tenacity properties of yarns. Since wet tenacity value of cotton yarn is higher than its dry tenacity value, these limited numbers of studies are concerned with cotton yarn (2, 12, 13, 14, 15) and except that there is only one study performed with 67 % PES - 33 % viscose yarns (5). Since the number of studies about the effects of vacuum steaming processes on physical properties of yarns is limited and especially cotton yarns have higher wet tenacity values (1), we have chosen 100 % cotton and 100% viscose yarns for this study.

2. MATERIAL AND METHOD

In the study, 30 Ne and 16 Ne 100 % cotton and 100 % viscose yarns with αe=4, αe=5 and αe=7 were used. The fineness and length of the viscose fibres used were 1.2 denier and 38 mm respectively. The properties of the cotton fibres were given in Table 1. The yarn numbers and twist coefficients used in this study have been chosen from the values which are widely used in textile industry.

Table 1. Properties of cotton fibres

% 25 Length	28,2
Uniformity	82,5
Micronaire value	4,4
Tenacity (cN/Tex)	31,1
CG (Colour)	41-4
Rd (Luster)	70,9
+b (Yellowness)	9,1

The yarns were exposed to vacuum steaming under the conditions given in Table 2 in order to examine the effects of the temperature and duration. Vacuum steaming temperatures and durations used in this study were determined by taking into account vacuum steaming temperature and duration values employed at textile factory and those given in the catalogues and documents of the manufacturers of vacuum steaming machines (7-9, 11, 16).

These yarns were subjected to vacuum steaming on Obem (Italia), a vacuum steaming machine which works on the direct method and provides 75% vacuuming and the below given circle was followed in the application of vacuum steaming.

1. Initial vacuum : 2 minutes, -600 mm/hg
2. Heating : Duration varies depending on the heat desired
3. Waiting : 30, 40, 50 minutes at 70 ˚C, 80 ˚C, 90 ˚C
4. Vacuum balance : 2 minutes at - 600 mm/hg

Tenacity properties of the yarns were measured after the yarns were conditioned for 24 hours under the standard conditioning (20 ± 2 ºC and 65% ± 2 of humidity). The measurements of yarn count were made according to EN ISO 2060 (17) and measurements of yarn twists were carried out according to EN ISO 2061 (18). Tenacity tests of the yarns were performed using Uster Tensorapid equipment according to EN ISO 2062. Breaking loads (cN), breaking tenacity (cN/tex), breaking elongation (%), elasticity module (N/Tex**)** and work of rupture (N.cm) of all the yarns were measured before and after vacuum steaming (19).

The effects of vacuum steaming temperature and duration on the tenacity properties of the cotton and viscose yarns were evaluated in SPSS program, using variance analysis and SNK (Student Newman Keuls Test) test results at 5% (0.05) level of significance.

3. RESULTS AND DISCUSSION

In this part the effect of vacuum steaming duration and temperature on tenacity properties of 16 Ne and 30 Ne cotton and viscose yarns was evaluated using the SNK results given in Table 3 and 4, and percentage changes on the tenacity properties given in Table 5 and 6.

Table 2. The properties of vacuum steaming processes applied to cotton and viscose yarns

Material	Twist Coefficient	Linear Density	Vacuum Steaming Temperature	Vacuum Steaming Duration (Minute)
100 % Cotton and 100 % Viscose yarns	α_e= 4, 5, 7	16 Ne 30 Ne	70 ºC	30
				40
				50
			80 ºC	30
				40
				50
			90 ºC	30
				40
				50

Table 3. SNK test results of the cotton yarn

Material	Factor	Breaking Load (kN)		Breaking Tenacity (N/Tex)		Breaking Elongation (%)		Young Module (N/Tex)		Work of Rupture (J)	
		16 Ne	30 Ne	16 Ne	30 Ne	16 Ne	30 Ne	16 Ne	30 Ne	16 Ne	30 Ne
100 % Cotton yarn	**Twisting Coefficient (α_e)**										
	4	0,0060(2)	0.0029(1)	0,1690(2)	0,1547(2)	0,0799(1)	0,0715(1)	2,57(3)	2,88(2)	0,1081(1)	0,0426(1)
	5	0,0063(3)	0,0032(2)	0,1712(2)	0,1674(3)	0,0907(2)	0,0651(1)	2,50(2)	2,80(2)	0,1130(1)	0,0508(2)
	7	0,0053(1)	0,0028(1)	0,1332(1)	0,1386(1)	0,1086(3)	0,0999(1)	1,74(1)	2,07(1)	0,1195(2)	0,0529(2)
	Vacuum Steaming Temperature (ºC)										
	70	0,0060(2)	0,0030(1)	0,1610(2)	0,1547(1)	0,0943(1)	0,0917(1)	2,29(1)	2,61(1)	0,1175(2)	0,0495(1)
	80	0,0059(1)(2)	0,0029(1)	0,1594(2)	0,1535(1)	0,0909(1)	0,0663(1)	2,27(1)	2,57(1)	0,1159(2)	0,0484(1)
	90	0,0057(1)	0,0030(1)	0,1529(1)	0,1525(1)	0,0939(1)	0,0785(1)	2,26(1)	2,56(1)	0,1071(1)	0,0485(1)
	Vacuum Steaming Time (min)										
	30	0,0057(1)	0,0030(1)	0,1528(1)	0,1548(1)	0,0903(2)	0.0667(1)	2,22(1)	2,61(1)	0,1108(1)	0,0488(1)
	40	0,0059(1)	0,0049(1)	0,1596(2)	0,1512(1)	0,0859(1)	0,0932(1)	2,31(2)	2,56(1)	0,1133(1)	0,0475(1)
	50	0,0059(1)	0,0030(1)	0,1611(2)	0,1548(1)	0,1030(3)	0,0766(1)	2,30(2)	2,58(1)	0,1164(1)	0,0500(1)

Table 4. SNK test results of the viscose yarn

Material	Factor	Breaking Load (kN)		Breaking Tenacity (N/Tex)		Breaking Elongation (%)		Young Module (N/Tex)		Work of Rupture (J)	
		16 Ne	30 Ne	16 Ne	30 Ne	16 Ne	30 Ne	16 Ne	30 Ne	16 Ne	30 Ne
100 % viscose yarn	**Twisting Coefficient (α_e)**										
	4	0,0058(3)	0,0030(2)	0,160(1)	0,1543(2)	0,1578(1)	0,1350(2)	2,25(2)	3,02(2)	0,2602(3)	0,1188(2)
	5	0,0055(2)	0,0029(2)	0,145(1)	0,1494(2)	0,1525(1)	0,1355(2)	2,41(3)	2,91(2)	0,2441(2)	0,1171(2)
	7	0,0040(1)	0,0021(1)	0,127(1)	0,0983(1)	0,1540(1)	0,1221(1)	1,29(1)	1,81(1)	0,1732(1)	0,0767(1)
	Vacuum Steaming Temperature (ºC)										
	70	0,0052(2)	0,0027(1)	0,167(1)	0,1341(1)(2)	0,1564(2)	0,1337(1)	2,03(2)	2,54(1)	0,2348(2)	0,1079(1)
	80	0,0052(2)	0,0027(1)	0,134(1)	0,1382(2)	0,1574(2)	0,1304(1)	1,90(1)	2,65(1)	0,2328(2)	0,1048(1)
	90	0,0049(1)	0,0026(1)	0,132(1)	0,1296(1)	0,1505(1)	0,1284(1)	2,02(2)	2,55(1)	0,2099(1)	0,0999(1)
	Vacuum Steaming Time (min)										
	30	0,0051(1)	0,0027(1)	0,162(1)	0,1319(1)	0,1532(1)	0,1322(1)	2,07(2)	2,51(1)	0,2242(1)	0,1053(1)
	40	0,0052(1)	0,0027(1)	0,136(1)	0,1375(1)	0,1550(1)	0,1298(1)	2,00(2)(1)	2,67(1)	0,2290(1)	0,1057(1)
	50	0,0051(1)	0,0026(1)	0,135(1)	0,1325(1)	0,1562(1)	0,1305(1)	1,89(1)	2,56(1)	0,2243(1)	0,1016(1)

Table 5. Percentage changes in tenacity properties of the cotton yarn

Material	Twisting Coefficient (αe)	Vacuum Steaming Conditions		Percentage Changes at physical properties of yarns (%)									
				Breaking Load		Breaking Tenacity		Breaking Elongation		Young Module		Work of Rupture	
		Temp.	Duration (Minute)	16 Ne	30 Ne	16 Ne	30 Ne	16 Ne	30 Ne	16 Ne	30 Ne	16 Ne	30 Ne
100 % Cotton yarn	4	70 ºC	30	1,10	6,37	0,32	2,08	16,53	2,25	4,02	-8,73	16,22	-3,46
			40	7,29	-6,15	5,71	6,49	22,68	9,04	-3,30	4,49	27,36	-8,17
			50	4,96	-2,32	-4,29	1,38	22,70	-3,22	-7,51	-18,08	23,19	-16,03
		80 ºC	30	9,31	-2,14	2,16	-0,61	20,83	6,36	-4,50	-18,14	27,89	-4,47
			40	1,49	-1,77	0,05	-1,14	21,87	10,98	-4,43	-30,56	20,19	2,21
			50	0,86	9,33	0,52	9,40	20,13	12,84	-4,41	-11,79	19,92	15,35
		90 ºC	30	9,66	-9,60	1,03	-11,41	20,59	-1,65	-7,77	-17,53	29,94	-16,75
			40	3,46	-0,32	1,24	6,31	27,38	7,31	-8,08	-10,47	22,77	-1,52
			50	-2,70	-2,73	-8,33	2,33	15,49	10,42	-5,51	-19,42	10,20	-1,98
	5	70 ºC	30	3,81	4,94	-2,49	1,99	13,16	-0,15	-10,20	-27,09	12,77	-8,46
			40	9,95	5,77	11,88	-2,41	23,50	16,59	0,50	-10,92	29,02	3,04
			50	10,33	23,83	10,52	22,39	13,24	27,27	-2,69	-3,57	20,06	35,31
		80 ºC	30	11,41	12,80	12,56	15,72	27,48	18,48	1,60	14,32	33,27	13,78
			40	10,80	-2,23	4,10	6,69	31,88	8,36	-9,84	6,027	33,85	-4,38
			50	1,40	11,23	-0,64	14,53	20,53	5,58	-7,48	-10,92	14,45	6,80
		90 ºC	30	-1,46	8,53	-5,10	8,67	9,46	-6,65	-11,12	-16,28	4,08	-9,49
			40	2,65	-0,03	0,70	-3,23	22,95	-14,56	2,25	-7,89	18,12	-22,31
			50	10,64	23,12	5,82	24,30	33,24	23,03	2,64	6,03	31,45	19,48
	7	70 ºC	30	5,38	15,05	0,07	8,04	55,97	67,97	-7,57	18,89	14,49	22,68
			40	-11,88	17,35	-14,09	1,79	-2,46	6,74	4,12	-23,59	-3,06	6,31
			50	13,87	14,30	13,59	14,95	23,19	6,30	-2,28	2,85	24,73	14,78
		80 ºC	30	2,20	20,92	1,87	12,87	19,49	0,49	15,36	3,47	11,04	21,28
			40	4,09	4,02	-2,72	-0,90	21,88	20,13	1,17	8,13	16,00	16,33
			50	-8,54	19,35	-1,50	12,17	-5,41	-0,96	0,98	-0,63	-8,68	21,37
		90 ºC	30	8,90	-11,81	-0,07	-20,17	16,45	7,17	-8,63	-1,03	16,39	-9,82
			40	23,12	-6,80	28,84	-12,30	21,82	-8,93	10,06	-12,50	35,35	-18,72
			50	3,39	14,47	2,03	1,01	23,58	8,96	7,53	-2,57	11,86	12,68

Table 6. Percentage changes in tenacity properties of the viscose yarn

Material	Twisting Coefficient (αe)	Vacuum Steaming Conditions: Temp.	Vacuum Steaming Conditions: Duration (Minute)	Breaking Load 16 Ne	Breaking Load 30 Ne	Breaking Tenacity 16 Ne	Breaking Tenacity 30 Ne	Breaking Elongation 16 Ne	Breaking Elongation 30 Ne	Young Module 16 Ne	Young Module 30 Ne	Work of Rupture 16 Ne	Work of Rupture 30 Ne
100 % viscose yarn	4	70 ºC	30	-19,10	-7,84	-17,33	-15,70	-7,02	-2,82	15,07	-15,08	-25,59	-14,44
			40	-12,37	0,55	-15,32	0,62	-2,80	-7,25	9,20	2,08	-14,90	-9,30
			50	-5,91	-0,52	-5,26	4,56	1,44	-2,42	7,92	-7,18	-7,33	-8,58
		80 ºC	30	-8,06	-0,19	-13,53	-1,40	5,21	-5,65	6,60	-1,71	-6,76	-8,93
			40	-18,01	0,26	-19,36	1,80	-3,47	5,04	-10,32	-22,83	-21,83	-3,11
			50	-14,11	3,95	-14,24	7,05	1,43	-2,81	-12,81	-19,01	-15,36	-2,75
		90 ºC	30	-16,88	-3,08	-13,69	-3,62	-6,52	-5,08	6,26	-13,20	-23,11	-12,71
			40	-15,42	13,21	-16,77	14,88	0,00	5,46	-2,92	-0,06	-17,45	11,50
			50	-12,67	-11,61	-11,45	-6,83	5,19	17,49	-30,16	-33,56	-15,40	-6,07
	5	70 ºC	30	-11,14	4,26	-3,32	0,87	2,54	4,49	27,42	-1,49	-12,11	2,65
			40	-12,47	6,89	-17,22	12,09	-0,19	-0,28	8,14	10,46	-14,41	1,94
			50	-23,25	-5,85	-28,98	-5,67	-17,93	-9,27	-2,42	-5,13	-34,26	1,52
		80 ºC	30	-10,93	37,06	-16,47	47,97	-4,35	56,30	14,07	7,05	-14,81	94,75
			40	-8,56	57,36	-9,94	74,70	0,60	79,27	-9,74	-9,76	-10,60	132,54
			50	-13,17	48,64	-15,28	54,88	-5,36	74,77	11,67	12,02	-17,67	114,83
		90 ºC	30	-8,28	45,85	-10,35	45,21	-1,98	64,34	36,31	-14,59	-11,00	104,86
			40	-6,43	51,26	-2,30	51,26	-3,21	63,72	10,51	-11,87	-10,49	108,46
			50	-8,04	23,16	-0,71	31,05	1,25	37,05	21,95	6,56	-10,70	47,89
	7	70 ºC	30	-16,88	3,06	-10,15	7,30	-7,79	-9,96	51,93	-11,57	-22,22	-5,28
			40	-11,97	3,22	-7,94	3,61	-1,56	6,08	33,33	-11,55	-13,74	-0,98
			50	-19,40	3,46	-8,80	2,49	-4,85	13,52	18,57	-27,01	-22,46	9,45
		80 ºC	30	-6,62	1,46	-6,82	5,67	-1,14	2,48	34,38	0,00	-6,41	-1,60
			40	-10,48	-11,24	-9,21	-5,34	1,13	-11,49	49,93	-9,24	-9,76	-23,74
			50	-7,21	9,85	-4,34	9,57	1,38	7,46	3,53	-11,46	-6,54	10,66
		90 ºC	30	-7,81	-29,22	-7,67	-28,56	3,52	-45,26	-10,07	-19,22	-6,62	-45,70
			40	-10,06	9,54	-5,04	13,53	-3,85	24,01	53,57	5,27	-14,88	20,58
			50	-26,86	-7,30	-28,20	-16,80	-28,70	2,09	-6,87	-42,41	-42,10	-13,84

Percentage Changes at physical properties of yarns (%)

3.1. The Effect of Twist Coefficient

When we have a look at the SNK test results given in Table 3 and 4, we see that the cotton yarns with α_e =5 have the highest breaking load and breaking tenacity values and those with α_e =7 have the highest breaking elongation and work of rupture values. Besides, we see that the viscose yarns with α_e = 4 have higher average breaking load values than those with α_e = 5, and α_e =7. The reason why cotton and viscose yarns have the highest tenacity values at α_e =5 and α_e =4 is that the cotton and viscose yarn tenacity values rise as their twist coefficients increase until a optimum twist point and then begin to decrease after this (1, 20, 21). Also, it can be seen from the SNK test results given in Table 3 and 4 that the elasticity modules of the cotton and viscose yarns decrease while their twist coefficient increases. The highest average elasticity values are obtained at α_e =4 and α_e =5, and the lowest average elasticity value is obtained at α_e =7 because elasticity module, which indicates the resistance to elongation in textile materials, decreases as twist coefficient increases (1).

3.2. The Effect of Vacuum Steaming Temperature

As can be seen from percentage change values given in Table 5, vacuum steaming processes generally improve cotton yarn tenacity properties. This increase occurred at different duration and different temperature of vacuum steaming varies depending on twist coefficient of the yarn. The reason for the increase in the yarns is that wet cotton yarns have higher tenacity properties than dry ones and (21, 22) vacuum steaming eliminates the stress which occurs due to the fact that the fibrils inside the cotton fibres are bonded the fibres axis with α = 20 - 30º helix angle (22).

When we analyse the SNK test results given in Table 3, we see that the average breaking load, breaking tenacity and work of rupture values obtained after vacuum steaming at 70 ºC are higher than those obtained after vacuum steaming at 80 ºC and 90 ºC. It is clearly seen that the average breaking load, breaking tenacity and work of rupture values decrease as the temperature increases. Work of rupture of a yarn means work capacity which is of great significance for the following processes. Therefore, it is suggested that increases in the tenacity and elasticity of the yarn should not be assessed individually but together with its work capacity (14). This finding shows that cotton yarns are to suffer losses in their tenacity properties and the performance in the following processes as the temperature rises over 70 ºC. Vacuum steaming temperatures over 70 ºC can lead to permanent degradation of fibres and, consequently, some decreases in the tenacity values of cotton yarns take place (22).

In other studies investigating the changes which occur in the tensile properties of cotton yarns after vacuum steaming, it is seen that the temperature ranges between 50 ºC and 70 ºC and the tensile properties increase as the temperatures rise (12-15). Therefore, it is advisable that vacuum steaming temperature should be kept below 70 ºC so that maximum tenacity values of cotton yarns can be obtained.

When Table 5 is studied, it is seen that the yarns twisted at α=4 and α=5 give better results at 70 ºC and 80 ºC; however the yarns twisted at α=7 give good results at 90 ºC. These findings indicate that temperatures up to 70 ºC are sufficient for the yarns with normal twist coefficients from tenacity aspect of yarns. Twisting process induces tension within yarn and the twist liveliness is related with yarn twist and strain. Vacuum steaming process is used for reducing the yarn snarling tendency (twist liveliness) (23). Yarns are exposed to higher tension when twisting processes are performed with high twist coefficients (α=7); therefore, it will be convenient to vacuum steam cotton yarns at 90 ºC' in order to decrease this tension and twist liveliness caused by this tension.

From Table 5 it can also be seen that tenacity values of 16/1 Ne and 30/1 Ne cotton yarns show differences. It is known that tenacity values of yarns vary as their twist coefficients change (1, 20, 21). The best result for α=4 has been obtained at 80 ºC for 50 minutes while the best results for α=5 has been obtained at 70 ºC for 50 minutes. As for α=7, best results have been obtained at 80 ºC for 50 minutes. All these findings suggest that vacuum steaming temperature and duration should not be determined depending only on raw materials of yarns. Twist coefficient is an important factor in determining the temperature and duration of the vacuum steaming.

After the vacuum steaming, the elasticity module values of cotton yarns 16 Ne and 30 Ne have generally been observed to be decreased (Table 3) as the temperature of vacuum steaming rises from 70°C to 80°C and 90°C because elasticity module decreases as fibres (natural, regenerated) absorb water in their bodies (1).

When we analyze the SNK test results given in Table 4, it can be seen that the average breaking load, breaking tenacity and work of rupture values of viscose yarns decrease as the temperature of vacuum steaming rises from 70 ºC and 80 ºC to 90 ºC. If Table 6, which gives the percentage changes in tenacity properties of viscose yarn, is examined, it is seen that breaking load and breaking tenacity values of 16 Ne viscose yarn decrease. The decreases in the tenacity values of viscose yarns are expected after vacuum steaming since cellulose macromolecules which form viscose fibres are short and the attraction between these macromolecules is not very strong. Therefore, when a force parallel to fiber axis is applied on viscose fibres, bonds between macromolecules weaken, causing fibres to break. Breakages of wet viscose fibres take place more easily due to the swelling and sliding effects of water (1, 24).

However, when the changes which take place in tenacity properties of 30 Ne viscose yarns are taken into consideration, it is seen that some increases occur (Table 6). Although viscose yarns twisted especially at α=5 have shown positive changes in their tenacity values after being vacuum steamed at all temperatures and for all durations, the highest tenacity values have been obtained after vacuum steaming at 80 ºC for 40 minutes. These findings suggest that twist coefficients of yarns play an important role in determining the temperature and duration of vacuum steaming.

3.3. The Effect of Vacuum Steaming Duration

When the SNK test results given in Table 3 and 4 are examined, it is seen that vacuum steaming duration has no statistically significant effect on tenacity properties of 16 Ne and 30 Ne cotton and viscose yarns. However, that vacuum steaming duration has no significant effect on tenacity properties of yarns does not mean that it does not affect other properties of yarns. It is a well known fact that vacuum steaming parameters are important in improving efficiency in the following production processes because it decreases especially twist liveliness of yarns (4).

4. CONCLUSIONS

The following results have been obtained from this study, which aims to investigate the effects of vacuum steaming process parameters on tenacity properties of cotton and viscose yarns:

- Type of yarn raw material, yarn number and yarn twist coefficient play an important role in determining the temperature of vacuum steaming. As the yarn twist coefficient changes, the temperature of the vacuum steaming should be changed.
- It is seen that vacuum steaming processes generally improve cotton yarn tenacity properties. Cotton yarns with normal and low twist coefficients should be subjected to vacuum steaming at 70 °C so that they can get maximum tenacity values while the yarns with a high twist coefficient such as α = 7 should be subjected to vacuum steaming at 90°C in order to decrease twist liveliness values of yarns and avoid related problems. The effects of vacuum steaming duration on tenacity properties of 16 Ne and 30 Ne cotton yarns have been found to be statistically insignificant.
- The average breaking load, breaking tenacity, work of rupture and elasticity module values of viscose yarns decrease as the temperature increases from 70 °C to 80 °C and 90°C and it is suggested that only those with high twist coefficients should be subjected to vacuum steaming and the temperature should not exceed 70 °C. The effects of vacuum steaming duration on tenacity properties of 16 Ne and 30 Ne viscose yarns have been found to be statistically insignificant.

Since there are limited number of studies about vacuum steaming in textile literature although it has an important application area in textile plants, it can be suggested that the performance of the vacuum steamed yarns in the following processes, the effects of vacuum steaming on twist liveliness of the yarns produced with different twisting methods and the effects of vacuum steaming on the degree of spirality at knitted cloth and the effects of vacuum steaming on the changes in hairiness values should be taken into consideration.

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