(REFEREED RESEARCH)

THE PROPERTIES OF STIFFNESS AND ABSORBENCY IN KNIT TOWEL FABRICS

ÖRME HAVLU KUMAŞLARDA SERTLİK VE EMİCİLİK ÖZELLİKLERİ

Seval UYANIK[1], Belkıs ZERVENT ÜNAL[2]

1Gaziantep University, Technical Sciences Vocational School, Gaziantep, Turkey
[2]Çukurova University, Textile Engineering Department, Adana, Turkey

Received: 08.01.2018 Accepted: 01.08.2018

ABSTRACT

This paper examines the effects of fabric structural parameters such as pile yarn count (Ne 30, Ne 26 and Ne 24), ground yarn count (90 Td and 70 Td), and pile loop height (2.2 mm, 2.5 mm and 2.8 mm) on the properties of stiffness and absorbency in the pile loop and the cut-pile loop knit fabrics. For this aim, thirty samples were produced and then the absorbency and softness values of these samples were tested with standard test methods. Consequently, it was seen that sinker height and pile cut process have been effective on hydrophilicity and softness.

Keywords: Pile loop knit fabric, cut-pile loop knit fabric, fabric stiffness, water absorbency, pile height, yarn number.

ÖZET

Bu makale havlu ve kadife örme kumaşlarda sertlik ve emicilik özellikleri üzerine hav ipliği numarası (Ne 30, Ne 26 ve Ne 24), zemin ipliği numarası, (90 denye ve 70 denye) ve hav yüksekliği (2.2 mm, 2.5 mm ve 2.8 mm) kumaş yapısal parametrelerinin etkisini incelemektedir. Bu amaçla otuz numune üretilmiştir ve sonra ilgili standartlar aracılığıyla bu numunelerin emicilik ve yumuşaklık değerleri test edilmiştir. Sonuç olarak, platin yüksekliği ve hav kesme işleminin hidrofilite ve yumuşaklık üzerinde etkili olduğu görülmüştür.

Anahtar Kelimeler: Havlu örme kumaş, kadife örme kumaş, kumaş sertliği, su emiciliği, hav yüksekliği, iplik numarası.

Corresponding Author: Seval Uyanık, uyanik@gantep.edu.tr

INTRODUCTION

Pile loop knit fabrics are widely used by the apparel industry for sportswear and bathrobes due to their good comfort, touch, and aesthetic properties. Plush fabrics or terry fabrics are obtained by knitting two yarns at the same feeder; a ground yarn knitting plain jersey structure that visible at the fabric front side and a plush yarn knitting plain jersey forming plush loop that visible at the fabric back side in pile and plush structures the pile and plush is clearly distinguishable from the base. Pile is considered to stand out at right-angles to the base, whereas plush lies at less of an angle from the base surface (1). The elongated sinker loops are formed over a higher knock-over surface than the normal-length ground sinker loops with which they are plated. The sinker loops show as a pile between the wales on the technical back of the fabric. Cut-pile loop is achieved during finishing; by cropping or shearing the sinker loops in both directions. This leaves the individual fibers exposed as a soft cut-pile loopy surface whilst the ground loops remain intact (2). On the sinker top latch needle machine, the ground yarn is fed into the sinker throat and the sinker is then advanced so that the pile loop yarn fed at a higher level (Figure 1) is drawn over the sinker nib. A range of pile loop heights from 2 to 4 mm is possible using different heights of sinker (2).

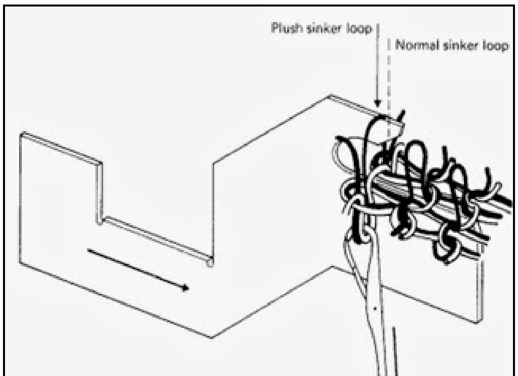

Figure 1. Pile loop formation (2)

As shown in Figure 2, terry (pile loop) fabric can also be knitted on a single knit machine. The face of the fabric is jersey and the terry loops of yarn appear on the technical back of the unfinished fabric. Therefore the fabric is turned inside out for finishing. During finishing, the tops of the loops are sheared, converting a knit terry into terry velour. This produces a soft plush surface on the fabric (3).

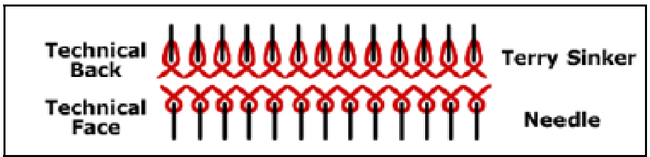

Figure 2. Terry fabric needle diagram (4)

Many studies have reported that the mechanical properties of knitted fabrics vary according to knit structures, fibers, yarns, and densities, which in turn affect the knit's hand significantly. Although there are many studies related to the properties of single jersey and its derivatives, a few studies are available about pile loop knit fabrics in the literature.

Knapton et al. (5-7) reported that the dimensional stability and knit performance of the fabrics are influenced by components such as knit structure, stitch length, and cover factor.

Anand and Lawton (8-9) studied pile-loop knit fabric and presented several empirical models to predict dimensional parameters such as course density, wale density, and stitch density. They reported that the dimensional parameters of pile loop knit fabrics are largely controlled by the stitch length in the ground structure and the state of relaxation. In another study, the same researchers (10) investigated the performance of several knit fabrics, such as pile loop knit, 1x1 knit/miss, and 1x1 cross-inlay, when used as dust filters.

Choi and Ashdown (11) focused on the mechanical properties of weft knits for outerwear as a function of knit structure and density and the relationships between hand, structure, and density in their studies. They reported that tensile properties, stiffness and fullness increase but, compression values, softness and smoothness decrease as knit density increases.

Kim et al. (12) analysed the effect of chemical splitting on the mechanical properties and water absorption of a split-type nylon/polyester microfiber pile knit under various alkaline hydrolysis treatment conditions. They found that hydrolysis parameters and sodium hydroxide concentration affected mass loss of hydrolysed pile knits and their mechanical properties.

Ucar and Canbaz Karakas (13) investigated some physical properties of pile loop knit fabrics. In this study, they showed that the effects of pile type, fiber type, fabric tightness, and relaxation on the physical properties of pile-loop knit fabrics are important. They determined that cut-pile fabric shows more dimensional changes and less spirality than pile-loop fabric. In addition to this, the ground-face fabric has more drapability than the pile-face fabric. Also, there is no significant relationship between pile type and drape coefficient.

Uyanik et al. (14) examined that the effect of fabric structural parameters on dimensional and aesthetic properties in pile loop and cut-pile loop knit fabrics. They found that the higher pile height increases fabric shrinkage, reduces spirality in pile loop fabrics, and increases spirality in cut-pile loop fabrics. In pile loop fabrics, the thicker pile yarn increases shrinkage in wale direction and increases spirality. Ground yarn number is not effective on dimensional stability and spirality.

Uyanik (15) investigated the performance properties such as abrasion resistance, bursting strength, and air permeability of the pile loop and cut-pile loop fabrics. She determined that the bursting strength increases with thicker ground yarn, and the thicker pile yarn reduces the air permeability. Pile loop knit fabrics have higher abrasion resistance and lower air permeability in comparison to cut-pile loop knit fabrics. There is not much difference between the bursting strength of pile loop and cut-pile loop knit fabrics if the linear density of ground and pile yarn is the same.

As seen in previous works, there are no studies on the absorbency properties of pile loop knit fabrics or cut-pile loop knit fabrics. In addition to this, the studies investigating the effects of all factors together, which are pile yarn number, ground yarn number, pile height and pile type, on these fabrics are not found.

In this study taking into account the aforementioned circumstances, it was aimed to investigate the effects of yarn numbers and pile heights on the properties of stiffness and absorbency in pile loop and cut-pile loop knit fabrics. So it is thought that the study in these respects will contribute to the literature.

MATERIALS AND METHODS

Material

In this research, eighteen pile loop knit fabrics and twelve cut-pile loop knit fabrics were produced by using 100% carded cotton ring spun pile yarns and 100% polyester filament ground yarns. The pile yarns are three yarn numbers as Ne 30, Ne 26, Ne 24 and the ground yarns are two yarn numbers as 90 denier and 70 denier. Pile yarn properties were given in Table 1.

Method

Pile loop knit fabrics were produced by using three different sinker heights (2.2 mm, 2.5 mm and 2.8 mm). The machine properties were given in Table 2.

Table 1. Pile yarn properties

Yarn number, Ne	Breaking strength, rkm	Breaking elongation, %	Twist, tpm
30	15.4	4.6	820
26	16.9	4.6	768
24	18.3	5.0	733

Table 2. Knitting machine specifications

Sinker height, mm	2.2	2.5-2.8
Machine type	Orizio-JSVRN	Keumyong-KM-3SV
Gauge	20	20
Diameter, inch	30	30
Feed number	44	44
Needles	1856	1896
Machine speed, rpm	20	20

Table 3. Finishing machine specifications

Process	**Machine type**
Pre-treatment	Erbatech
Dyeing	Erbatech
Drying	Elmego Tumbler
Shearing	Biancalani
Drying for relaxation	Brückner

Produced pile loop knit fabrics were dyed under the same conditions. Finishing process includes the basic stages which are kiering, dyeing, and drying processes, and the auxiliary stages which are washing and neutralization processes. In this phase, the pile loops formed by cotton yarns were dyed while the ground loops formed by polyester yarns were not dyed. Dyeing process was made pad-batch method which is semi-continuous method, and in terms of dye-stuff, hot brand reactive dye-stuff was used due to dyeing in high temperatures. Finishing process machines and stages were shown in Tables 3-4, respectively. Hence, the process diagrams of kiering and dyeing were displayed in Figure 3 and Figure 4, respectively. Then, dyed pile loop fabrics with 2.5 mm and 2.8 mm were sheared to make cut-pile loop fabric, on the other hand the pile loop fabrics with 2.2 mm were not sheared owing to this pile height value was too short to cut. In the last phase of finishing processes, the relaxation process was made for pile loop fabrics and cut-pile loop fabrics to give dimensional stability.

Table 4. Finishing process

Processes		**Process Conditions**
Pre treatment	Kiering	95 °C, 45'
	Washing	30 °C, 10'
	Neutralization	35 °C, 15', pH 7
Dyeing	Reactive dyeing	60 °C, 60'
	Washing	30 °C, 10'
	Neutralization	35 °C, 15', pH 7
	Washing with soap	90 °C, 30'
	Washing with soap	80 °C, 30'
	Washing	60 °C, 10'
Drying		140 °C, 14 m/min
Shearing		15 m/min

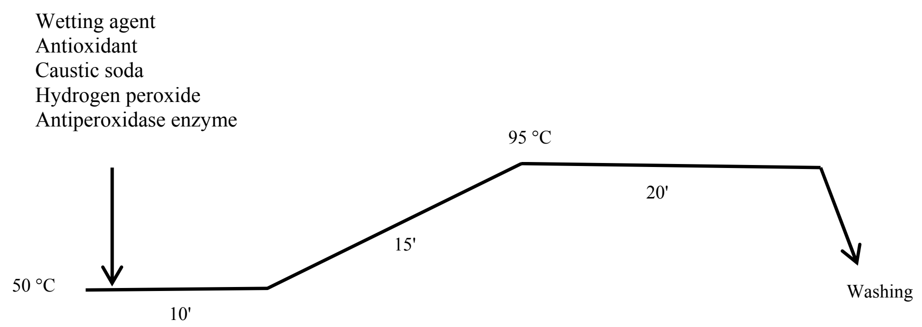

Figure 3. Kiering process diagram

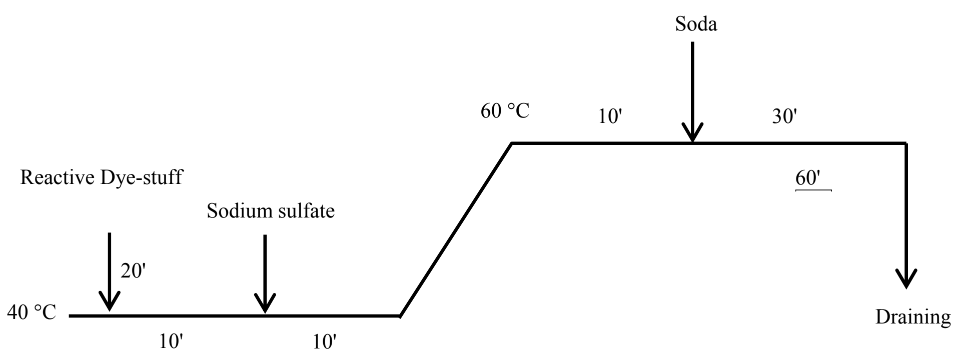

Figure 4. Dyeing process diagram

All the samples were conditioned in accordance with the standard ASTM D1776-08 before testing. The physical properties i.e. course density (cpc), wale density (wpc), stitch density (cpc x wpc), pile/ground ratio, weight, and thickness were measured according to standards EN 14971, TS 629:2015, EN 12127, and EN ISO 5084, respectively. Stiffness and water absorption tests were applied for all fabrics in accordance with ASTM D4032-94 and TS 866 standards. MANOVA analysis was made in order to determine the relationships between variables and the significance of each factor's contribution. For this aim the statistical software package SPSS 21.0 was used to interpret the experimental data. All the test results were assessed at significance levels p ≤ 0, 05 and p ≤ 0, 01.

RESULTS AND DISCUSSION

The properties of pile loop and cut-pile loop knit fabrics were given in Table 5. To identify the samples, the pile loop knit fabrics are coded as P while the cut-pile loop knit fabrics are coded as C. Sinker height and pile height were accepted as the same expressions since the pile height is determined according to the sinker height in the pile knit fabrics. So, sinker height term was used on the following parts.

Structural Properties

According to Table 5, it was seen that cource density (cpc), wale density (wpc), stitch density (number of stitches/cm^2) and pile/ground ratio values of the samples produced in the same machine were same or very close to each other, because machine settings were not changed during production. Fabric weight and thickness values of the samples varied depending on yarn number and sinker height. As expected, usage of thicker yarn and higher sinker height increased the weight and thickness values of the samples. All cut-pile loop samples were expectedly lighter and thinner than pile loop samples because of shearing the pile loop of fabrics. As a result of this, cut-pile loop samples lost weight approximately 19% to 28% and these samples were thinner as ratio of 14% to 30% in comparison to pile loop samples.

Stiffness

When Figure 5 is examined, it can be usually said that pile loop fabrics have higher stiffness values than cut-pile loop fabrics. The samples with 2.8 sinker have higher stiffness values for both pile loop and cut-pile loop fabrics. In the pile loop fabrics, samples with 2.2 sinker are stiffer than samples with 2.5 sinker. There is an increase trend for stiffness by decreasing pile yarn number. In other words, thicker pile yarns increase stiffness values except some samples. Samples containing 90 Td ground yarn have higher stiffness values than samples containing 70 Td ground yarn in pile loop fabrics whereas the stiffness values are close for both of them in cut-pile loop fabrics. Hence, the pile loop samples with 2.8 sinker have higher stiffness than those of the cut-pile loop samples considering the same ground yarn number. The sample of which pile yarn number is Ne 24, ground yarn number is 90 Td, sinker height is 2.8 has the highest stiffness value (the stiffest sample). It was determined that the softest sample is sample code P1 (ground yarn 90 Td, pile yarn Ne 30 and sinker height 2.2).

Table 5. The properties of the pile loop and cut-pile loop samples

Samples	Fabric type	Yarn number		Sinker height (mm)	cpc	wpc	Stitch density (cpc x wpc)	Pile/ground ratio	Weight (g/m²)	Thickness (mm)	Stiffness (kgf)	Water absorbency (sec)
		Ground (Td)	Pile (Ne)									
P1	pile	90	30	2.2	12.5	9	112.5	2.23	214.35	1.58	0.040	8.64
P2	pile	90	30	2.5	12.5	9	112.5	2.53	230.87	1.85	0.075	15.6
P3	pile	90	30	2.8	14	10	140	2.62	259.76	1.94	0.085	18.7
P4	pile	90	26	2.2	12.5	9	112.5	2.23	250.19	1.75	0.065	7.2
P5	pile	90	26	2.5	13	9	117	2.47	259.34	1.83	0.075	8.9
P6	pile	90	26	2.8	15	9.5	142.5	2.69	319.22	2.18	0.100	7.2
P7	pile	90	24	2.2	12.5	9	112.5	2.22	268.48	1.85	0.100	8.6
P8	pile	90	24	2.5	14	9	126	2.40	286.57	1.88	0.065	7.9
P9	pile	90	24	2.8	15.5	9.5	147	2.68	331.50	2.16	0.130	7.9
P10	pile	70	30	2.2	12	9	108	2.21	192.68	1.69	0.075	8.2
P11	pile	70	30	2.5	13	10	130	2.48	236.73	1.85	0.045	7.9
P12	pile	70	30	2.8	14	9.5	133	2.62	242.99	1.75	0.055	9.8
P13	pile	70	26	2.2	13	9	117	2.24	240.05	1.65	0.075	3.7
P14	pile	70	26	2.5	12.5	9.5	119	2.40	240.76	1.75	0.060	6.0
P15	pile	70	26	2.8	14	9.5	133	2.59	279.77	2.07	0.080	11.0
P16	pile	70	24	2.2	12.5	9	112.5	2.23	254.82	1.69	0.075	4.4
P17	pile	70	24	2.5	12.5	9	112.5	2.41	264.33	1.82	0.065	10.0
P18	pile	70	24	2.8	14.5	10	145	2.70	320.24	2.01	0.095	9.8
C1	cut-pile	90	30	2.5	13	9	117	-	171.22	1.29	0.045	12.4
C2	cut-pile	90	30	2.8	15	9.5	142.5	-	210.16	1.59	0.070	13.9
C3	cut-pile	90	26	2.5	13	9.5	123.5	-	203.07	1.41	0.065	7.2
C4	cut-pile	90	26	2.8	15.5	10	155	-	236.46	1.65	0.070	5.2
C5	cut-pile	90	24	2.5	13	9	117	-	204.37	1.40	0.070	5.7
C6	cut-pile	90	24	2.8	15	9	135	-	250.06	1.73	0.085	6.5
C7	cut-pile	70	30	2.5	13	9	117	-	168.92	1.31	0.055	23.8
C8	cut-pile	70	30	2.8	14	9.5	133	-	185.82	1.51	0.080	11.5
C9	cut-pile	70	26	2.5	12	9.5	112.5	-	185.89	1.32	0.060	8.7
C10	cut-pile	70	26	2.8	14.5	9.5	138	-	221.58	1.62	0.065	5.5
C11	cut-pile	70	24	2.5	12.5	9	112.5	-	190.05	1.35	0.070	7.7
C12	cut-pile	70	24	2.8	14	9.5	133	-	239.95	1.71	0.080	5.3

This part was discussed under four sub-headings as structural properties, stiffness, water absorbency, and statistical analyses.

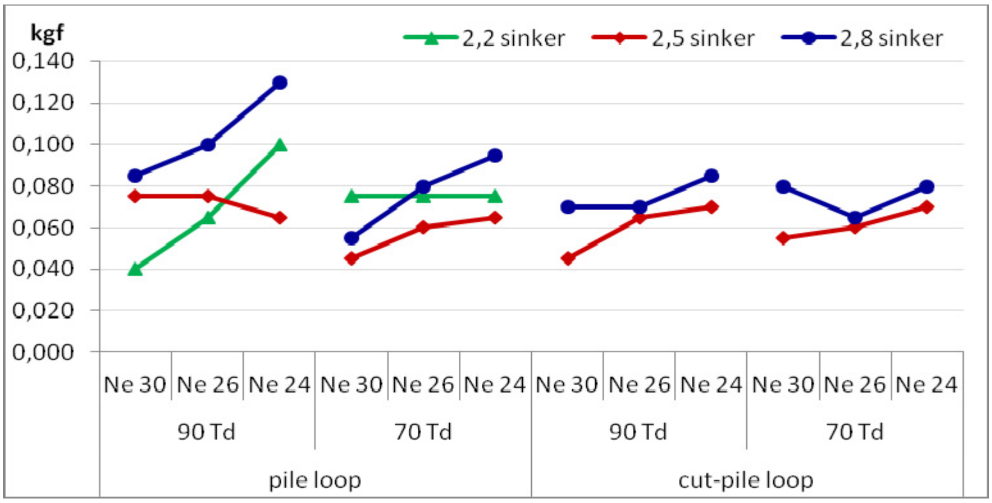

Figure 5. Stiffness

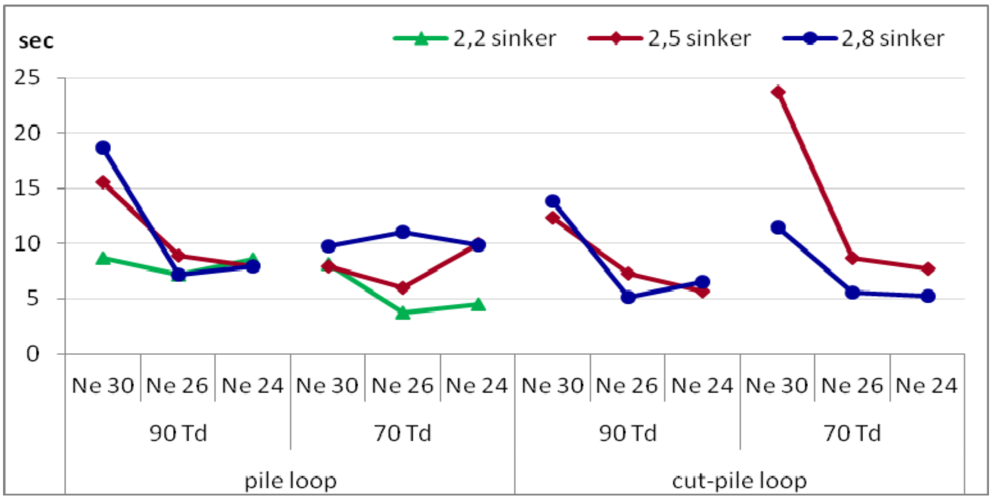

Figure 6. Water absorbency

Water absorbency

The test results and Figure 6 show that the sample of which pile yarn number is Ne 30, ground yarn number is 70 Td, sinker height is 2.5 has the lowest water absorbency. In addition to this, all samples containing Ne 30 pile yarn at different sinker height and ground yarn number have mostly lower water absorbency than the other samples. On the other hand, water absorbency values are very close for both of the samples having Ne 26 pile yarn and Ne 24 pile yarn. In the pile loop fabrics, it is seen that increasing sinker height reduces water absorbency whereas it increases water absorbency in the cut-pile loop fabrics. It is clear that pile yarn is more effective on water absorbency than ground yarn.

Statistical Analyses

MANOVA test results were displayed in Table 6. According to MANOVA results pile yarn has significant effects on stiffness and water absorbency whereas sinker height has significant effect on stitch density and stiffness. Furthermore, ground yarn is not effective factor on all fabric properties.

Table 6. MANOVA test results

Source	Dependent variable	F	Sig.
Ground yarn	Stitch density	1.922	0.191
	Weight	0.687	0.423
	Thickness	0.276	0.609
	Stiffness	0.672	0.428
	Absorbency	0.367	0.556
Pile yarn	Stitch density	0.520	0.607
	Weight	2.622	0.114
	Thickness	0.376	0.695
	Stiffness	**5.123**	**0.025**
	Absorbency	**5.477**	**0.020**
Sinker (pile) height	Stitch density	**59.517**	**0.000**
	Weight	1.869	0.196
	Thickness	1.737	0.218
	Stiffness	**5.595**	**0.019**
	Absorbency	1.507	0.261

Conclusion

Selected experimental and statistical results are summarized below.

- The pile cut process was caused the weight loss and thickness loss in important ratio. So, the raw material cost of the cut- pile loop towels is higher than that of the pile loop towels. The reason for this is the cutting of the ends of the pile.
- In general, the cut-pile loop samples were softer than the other. This may arise from the fact that when the piles are cut off, the yarn twist in parallel with the yarn ends are opened, and so the surface of towel becomes softer.
- According to results, the sinker height is more effective than the yarn number in softness values. As the sinker height increased, the pile loop and cut-pile loop towels hardened.
- Like softness, the water absorbency decreased with increase the sinker height. Especially, the lowest absorbency was obtained with the thin yarn (Ne 30) and high sinker height (2.8) for both the pile and cut-pile loop towels. This situation may be welded from falling easily upon each other of the piles obtained with these yarns.
- As the result of statistical analysis, it was seen that the relationships between stiffness and pile yarn number, stiffness and sinker height, absorbency and pile yarn number were significant statistically.

REFERENCES

1. Anonymous, 1996.
2. Spencer D.J., 2001, "Knitting Technology: A Comprehensive Handbook and Practical Guide", Woodhead Publishing Limited, Abington Hall, Cambridge, England.
3. Schäch W., 1989, "What Is Meant By Cut Plush", Knitting Technology.
4. http://www.academia.edu/9506343/ Weft_Knitting.
5. Knapton J.J.F., 1968, "Knitting Performance of Wool Yams: Effects of Yarn/Metal Friction, Stitch Length, and Cover Factor on Knitting Performance". Textile Research Journal, (31)8, pp: 22-28.
6. Knapton J.J.F., Ahrens F.J., Ingenthron W.W., and Fong W., 1968, "The Dimensional Properties of Knitted Wool Fabrics", Textile Research Journal, (3108), pp: 1013-1026.
7. Knapton J.J.F., 1968, "Geometry of Complex Knitted Structures", Textile Research Journal, (399), pp: 889-892.
8. Anand S.C. and Lawton P.J., 1987, "The Dimensional Properties of Single Jersey Loop Pile Fabrics, Part I: Studies of Fabrics with Flat Continuous-Filament Yarns Used in the Ground Structure", Journal of the Textile Institute, 78, pp: 326-348.
9. Anand, S.C. and Lawton, P.J., 1987, "The Dimensional Properties of Single Jersey Loop Pile Fabrics, Part II: Studies of Fabrics with Textured Continuous-Filament Yarns in the Ground Structure", Journal of the Textile Institute, 78, pp: 349-356.
10. Anand, S.C. and Lawton P.J., 1991, "The Development of Knitted Structures for Filtration", Journal of the Textile Institute, 82, pp: 297-308.
11. Choi M.S. and Ashdown S.P., 2000, “Effect of Changes in Knit Structure and Density on the Mechanical and Hand Properties of Weft-Knitted Fabrics for Outerwear". Textile Research Journal, 70, pp: 1033-1045.
12. Kim S.H., Kim S.J. and Oh K.W., 2003, "Water Absorption and Mechanical Properties of Pile-Knit Fabrics Based on Conjugate N/P Microfibers", Textile Research Journal, 73, pp: 489-495.
13. Ucar N. and Karakas, H.C., 2005, "Effect of Lyocell Blend Yarn and Pile Type on the Properties of Pile Loop Knit Fabrics", Textile Research Journal, 75, pp: 352-356.
14. Uyanik S., Zervent Unal, B. and Celik N., 2015, "Examining of the Effect of Fabric Structural Parameters on Dimensional and Aesthetic Properties in Pile Loop and Cut-Pile Loop Knit Fabrics", International Journal of Science and Research (IJSR), 4, Issue 9.
15. Uyanik S., 2016, "Investigation of the Effect of Pile Height and Yarn Linear Density on the Performance Properties of Pile Loop and Cut-Pile Loop Knit Fabrics", Fibres & Textiles in Eastern Europe, 24(1), pp: 95-100.