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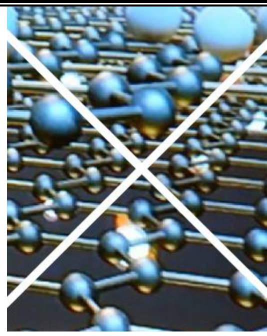

DRAPABILITY OF KNITTED FABRICS PRODUCED BY REGENERATED CELLULOSIC FIBERS VIA VORTEX SPINNING PRINCIPLE

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Abstract

This paper focuses on the drapability of knitted fabrics produced by different loop lengths and different raw materials. Selected raw materials (viscose, modal, bamboo, tencel and cotton) have similar characteristics because of the cellulosic origin. Regenerated cellulosic fibers are obtained by chemical processing of cellulose-based raw materials. They are similar to cotton in terms of their structural properties, but their performance characteristics have changed with the processes they have applied. There is no detailed study in the literature about the vortex spun yarns produced by regenerated cellulosic fiber; therefore this study will fill the lack of literature. Samples were produced by the principle of vortex spinning which has become very popular in recent years in terms of production speed and yarn quality. From these yarns, sample knitted fabrics were produced with different loop lengths by circular knitting machine. In this paper, the structural properties and drapabilities of the obtained samples were tested and the results were compared. Additionally, it was found that the effect of raw material is more effective parameter than the loop length on the drapability of plain knitted fabrics.

Keyword: Regenerated cellulosic fiber, Vortex spun yarn, Drapability

1.Introduction

Yarn made of natural and man-made cellulose fibers is nowadays commonly applied in textiles. Regenerated cellulose fibers show different properties depending on their manufacturing process as cross section, crystallinity and orientation [1].

Cellulose (Figure 1) is a polymer raw material used for two general purposes. For many centuries it has served mankind as a construction material, mainly in the form of intact wood and textile fibers such as cotton or flax, or in the form of paper and board. On the other hand, cellulose is a versatile [2]. Since the degree of orientation during the production of the fibers will also change the crystallinity of the structure, the softness, strength, absorbency and drapability levels of the produced fibers are likely to change. Cotton is a natural fiber of cellulose origin. These fibers are frequently used because of their permeability, absorbency and softness. Although these fibers are thin, they are good in strength. Also; their strength increases even more when they get wet. This can be advantageous during washing. Modal is a regenerated cellulosic fiber obtained by the modified viscose process. It has good wet and dry strengths compared to other regenerated cellulosic fibers. This is because chemicals added to the coagulation bath during production cause prolongation of cellulose molecules. It is a more absorbent fiber than cotton. These fibers are also preferred because they are thin and soft. Bamboo is an anti-bacterial natural fiber with high moisture transmission. The rapid growth of the fiber during the production without the need for pesticide and other chemicals is also effective on the antibacterial behavior of the fiber. However, its production is more expensive than organic cotton. At the same time, products made from this fiber keep cool in the hot summer season. It is a soft, UV resistant, anti-static and biodegradable fiber. It is popular because of its features. Tencel is a regenerated fiber which is preferred because of dry-wet strength and breathability [3].

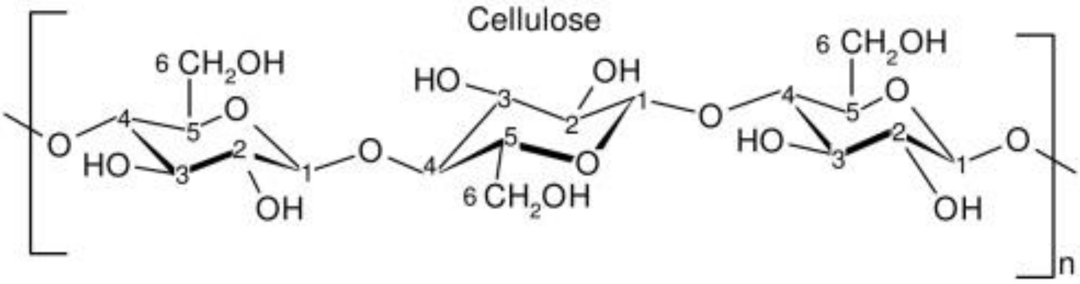

Figure 1. Chemical formula of cellulose and derivatives

Air vortex technology (Figure 2) is gaining momentum in spinning sector of the textile industry. This technology can be successfully used to produce the count range of Ne 30/1 and Ne 60/1 yarn with high quality [4]. The vortex spun yarn has a two-part structure (core and sheath). When the vortex yarn structure is examined, there are core fibers with no twist in the center and wrapping fibers which wind the core fibers with false twist. Air-vortex spinning systems based on spinning under the influence of compressed air have achieved commercially significant success due to their advantages such as high production speed, low processing steps, low personnel and space requirements, and ease of application of automation systems [5]. Count, twist, frictional behavior, bending rigidity, knots; yarn defects and yarn strength are playing critical role on deciding knitting performance of a yarn. Short fiber content is also playing a key role in knitting machine performance Moreover, count of the yarn should be suitable to machine fineness, and the twist of the yarn should not be very high, friction coefficient of the yarn should be low for knit-ability, to ensure softness bending rigidity should not be high and because of tension the number of knots should be low.

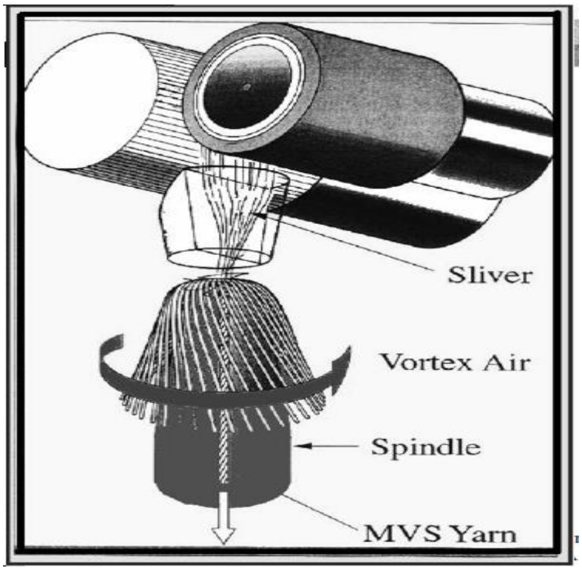

Figure 2. Principle of vortex spinning

In many studies, vortex yarn properties and other yarn production systems were compared with vortex yarn production system in literature [6-9]. When the yarn properties are examined, Murata Vortex Spinning (MVS) yarns according to conventional ring and open end- rotor yarns have moderate strength but have less hairy structure which results high pilling tendency. However, the drapability behavior of fabrics produced by vortex spinning technique is lower than that of ring spinning because of the stiffness. MVS spinning technology is favorable for short staple yarn spinning and produces a yarn with more rings –like appearance than Murata Jet Spinning technology [10]. Erdumlu et al. presented a comparison of the properties of Vortex, rotor and ring spun yarns made from 100% CO, 100% CV and 50/50 CO-modal fibers in relation to fabric knitted from these yarns [11].

In their study, Rameschkumar et al. compared the performance properties of fabrics produced from Ring, Rotor and Vortex yarns. With all three spinning systems, Ne 30 yarns of 100% cotton fiber were produced and fabric was formed in a single jersey knitting machine. Strength, smoothness, hairiness, bursting strength, abrasion resistance and pilling formation of the fabrics were examined [12]. In this study, tensile, evenness and hairiness of the yarns, bursting strength, abrasion resistance, pilling, drapability and color matching of the knitted fabrics were investigated. The ring spun yarns have high strength, low imperfection, and good bursting strength. Abrasion resistance of fabrics produced by Rotor and Vortex yarns were found higher than the fabrics produced by ring spun yarns. Knitted fabric from ring spun yarn has high bursting strength, knitted fabric from air-vortex spun yarn has poor drape due to stiffer yarn structure and the (MVS) yarn fabric has poor pilling resistance. Rotor, MVS yarns made fabrics have good abrasion resistance. Drape-ability of knitted fabric from air-vortex spun yarn was poor than knitted fabrics from ring and rotor yarn. Good and equal depth of dye shade was found with knitted fabrics produced by Ring and Air vortex spun yarn. Knitted fabric from ring spun yarn has shown smooth feeling than the other two fabrics [13]. This study examined the mechanical properties of micro modal yarns and knitted fabrics using ring, compact, and air vortex spinning techniques. The micro modal air vortex yarn was more irregular than those of the ring and compact yarns but there were significantly fewer and shorter hairy fibers on the air vortex yarn surface than those of the ring and compact yarns [14].In this paper, the hand and clothing comfort properties of hemp/tencel blend yarns and their knitted fabrics spun by ring, siro spun, and air vortex spinning machines.

The tactile clothing comfort properties of the air vortex yarn knitted fabric were influenced by the yarn mechanical properties resulting from the air vortex yarn structure. The high compressibility of the air vortex yarn knitted fabric made it soft and compressible to lateral deformation. The high extensibility and low bending rigidity of the air vortex yarn knitted fabric gave it a softer tactile hand property than those of the ring and siro-spun yarns knitted fabrics [15]. According to the available literature, there is no detailed study about the vortex spun yarns produced by regenerated cellulosic fiber, therefore this study will fill the lack of literature. The aim of the study is to produce knitted fabrics with three different loop length (loose, medium, tight) from regenerated cellulosic fibers (viscose, modal, bamboo, tencel) and cotton fibers, which are made into yarn by vortex spinning principle, and to compare the drapability properties of these fabrics.

2.Material and Method

Ne 30/1 yarns were produced from 6 different raw materials (cotton, modal, tencel, bamboo, viscose, cotton-modal) with vortex principle. Production parameters of raw material during vortex yarn spinning are given in Table 1.

Table 1. Production parameters of raw material

Raw material	Count of input sliver, Ne			Count of output sliver, Ne			Number of dublication			Speed of roving sliver, rpm			Production rate, m/min
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3	
Bamboo	0.12	0.14	0.16	0.14	0.16	0.17	6	6	8	500	500	500	370
Tencel	0.12	0.14	0.16	0.14	0.16	0.18	6	6	8	500	500	500	360
Modal	0.12	0.14	0.16	0.14	0.16	0.17	6	6	8	500	500	500	370
Viscose	0.12	0.14	0.16	0.14	0.16	0.17	6	6	8	600	600	550	420
Cotton	0.12	0.14	----	0.14	0.16	----	6	6	----	600	550	----	380

To compare the strength and elongation of vortex yarns according to raw material USTER Tester was used and the results are given in Table 2. During the test the rate of the test was 400m/min and 5 samples were tested then the average value was used. According to the Table 2; the strength of tencel fiber is the highest one while that of cotton fiber is the lowest. The breaking elongation of the cotton and tencel are close while their strength is very different because of the young modulus. Tencel's young modulus is very high so it is the stiffest one. Bamboo and viscose yarns are softer than the others. Hairiness of all samples is low and close to each other. To see the view difference of fibers microscopic views are taken and they are shown Table 3.

Table 2. Properties of yarns

Yarns	Unevenness, (%)	Coefficient of variation m., (%)	Hairiness (H)	Elongation (%)	Strength (cN/tex)	Young Modulus
Bamboo	11.09	13.98	4.08	10.46	14.60	1.39
Tencel	9.07	11.43	4.63	5.62	18.53	3.29
Modal	11.22	14.14	4.54	6.82	17.75	2.60
Viscose	10.37	13.21	4.82	8.47	13.54	1.59
Cotton	10.5	13.27	4.16	5.12	13.45	2.62

Table 3. Microscopic views of fibers and yarns

	Longitudinal views of yarns
Bamboo	
Viscose	
Modal	
Tencel	
Cotton	

It is known that the longitudinal view affects the luster and pilling tendency behavior which is depended on the smoothness of the structure. Therefore, it affects the softness. By the way, the smoothest fibers are cotton and tencel while the worst one is bamboo. The longitudinal views of yarns are similar to each other and the hairiness of all are low but the tencel's hairiness is the lowest one.
Using the produced yarns, 18 plain knitted fabrics were produced in SDL laboratory type single feeder circular knitting machine. Machine is 3.1 inch, 22 fein and it has 241 needles. By changing the tightness tight, medium and loose fabrics were obtained. The structural properties and the drapability of the fabrics were tested and analyzed by graphics and statistical methods. Drapability, considered to be one of the important properties for fabric, can be assessed by static and dynamic behaviors, which are mostly related to the beautiful appearance of clothes [8]. Drapability of a fabric is determined using Drape meter and is expressed in terms of Drape Co-efficient. A circular specimen of diameter 254 mm is supported on a circular disc of diameter 127 mm. When doing so, the unsupported area of the fabric drapes over the edge of the supporting disc. The drape coefficient, F is the ratio between the projected area of the draped specimen and its undraped specimen and its undraped area, after the deduction of the area of the supporting disc.

Ws = Weight of the paper whose area is equal to the projected area of the specimen,
Wd = Weight of the paper whose area is equal to the area of the supporting disc,
WD = Weight of the paper, whose area is equal to the area of the specimen,
F = Drape co-efficient,

The thickness of the paper to trace the outline must be uniform. The small value of F indicates better drape-ability of the fabric and the large values of F indicate the bad drape-ability [9]. In the Figure 3, Drape Cusick tester is shown.

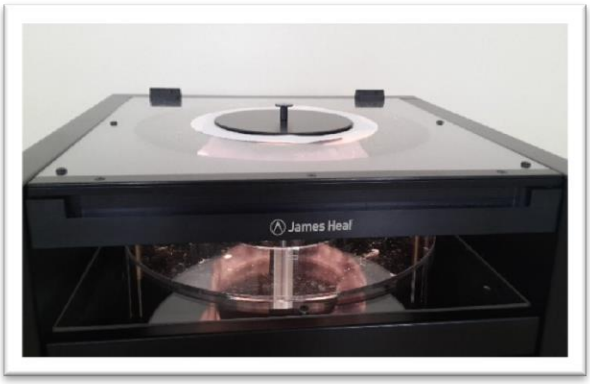

Figure 3. Drape tester

3.Results

The smallest unit that brings a knit surface is the loop. The resulting knitted surface consists of the loops connected to each other side by side and over the top. All dimensional and physical properties of a knitting structure depend on the shape, dimensions and other forms of binding of the loops forming the knitting. The length of the yarn that brings a loop to the thread is called the loop yarn length, which is measured at the loop axis. The loop length affects both the dimensional and physical properties of the knitted fabric. In order to produce a high quality and faultless knitted surface, loop length should be fed in each case constantly. If we do not knit patterned fabric, a constant yarn feeding system is required throughout the knitting process. All systems should be fed yarn at equal amount and tension. The loop length is provided by the yarn feed system and the yarn guide in the knitting machine [14]. Table 4 summarizes the structural properties of samples.

Table 4. Structural Properties of Samples

Raw Material	Tightness	Modal	Tencel	Bamboo	Viscose	Cotton	Cotton-Modal
Wale per cm, wpc	Tight	12	11	11	11	11	11
	Medium	11	10	11	11	11	12
	Loose	10	11	10	10	11	10
Course per cm, cpc	Tight	14	14	16	14	16	16
	Medium	13	11	13	12	13	13
	Loose	10	10	11	11	11	11
Weight g/m^2	Tight	105	108	187	102	114	108
	Medium	94	95	160	94	94	92
	Loose	91	97	125	84	88	88
Thickness mm	Tight	0.43	0.57	0.65	0.40	0.62	0.57
	Medium	0.44	0.46	0.61	0.38	0.60	0.55
	Loose	0.43	0.49	0.64	0.37	0.60	0.59

3.1.Drapability

While the unit weight of the fabric affects drapability, the stiffness provides resistance. For this reason, a stiff and heavy fabric may have similar drapability value to a loose and light fabric. The drapability of a fabric depends not only on its tightness but also on the resistance of the yarn to the change of the angle of the meshing, the resistance of the fabric to the distortion of the fabric and the ease of elongation. More elastic fabrics are more drapable than less elastic fabrics. Increasing the loop yarn length will cause the fabric to loosen and reduce the unit weight. The bending strengths of the fabrics are associated with the drapability. As the resistance to bending increases, the drapability decreases. As the fiber fineness decreases the bending resistance decreases while the bending length increases as the fiber thickens. The bending strength increases as the yarn thickness increases, while the strength decreases as the bending increases. As the fabric density increases and the loop length decreases, the bending strength and length increase [14]. Drapability test results are shown on Figure 4 as a graphic.

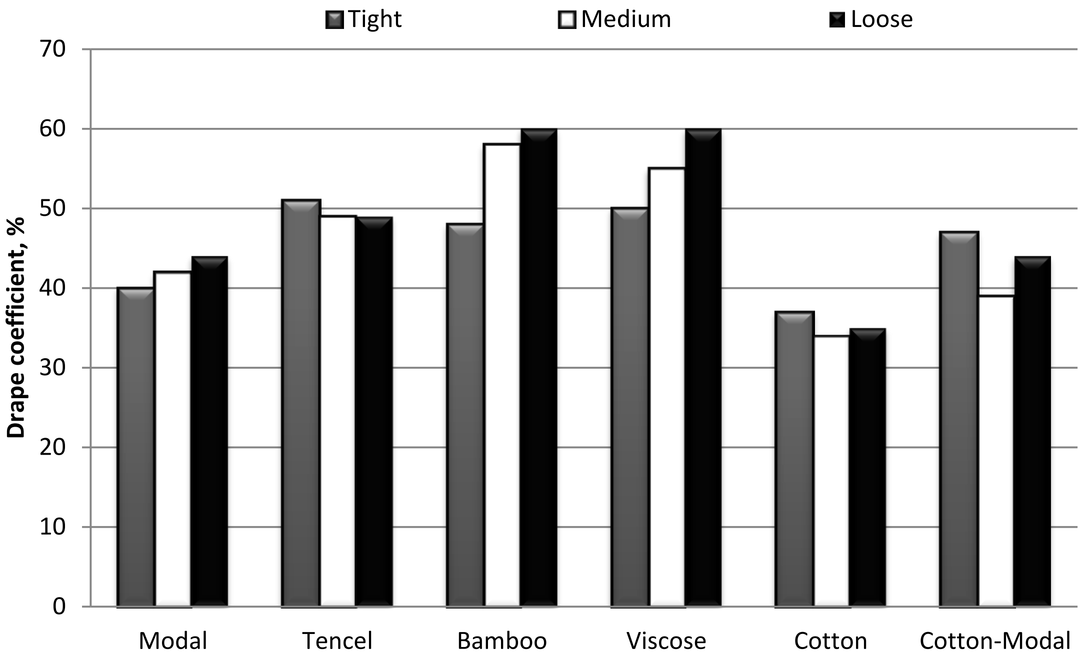

Figure 4. Drapability test results

It is known that; the higher the fabric drape coefficient, the lower the drapability and the stiffer the fabric. By evaluating the graphic, there is no linear relation between fabric tightness and drapability. Therefore, to reach the fabric with desired drapability raw material and tightness should determine together. According to the figure the softest fabric is cotton fabric knitted by medium tightness and the stiffest fabrics are bamboo and viscose fabrics knitted by high loop length (loose). With respect the weight and thickness of these fabrics, it is seen that these values are very different to each other, so it is concluded that neither weight nor thickness are not directly effective parameters on drapability. All the factors change the drapability.

3.2.Statistical Analyses

The experimental results have been statistically evaluated by Design Expert software with F values of the significance level of α=0.05. We evaluated the results based on the F-ratio and the probability of the F-ratio (prob>F). The lower the probability of the F-ratio, it is stronger the contribution of the variation and more significant the variable. Table 5, summarizes the statistical significance analysis for all data obtained. In the table, variables are the raw material, tightness and the interactions of these two parameters. Moreover, C % is the contribution in percent.

According to the table, statistically significant effect of raw material on weight, thickness and drapability was found significant. The tightness factor is not a statistically significant parameter other than the weight and cpc values of fabrics. When the impact factors are considered, the impact on the drapability is quite high.

Table 5. Statistical significance analysis of the data for the fabrics

Fabric Properties		**Wpc**	**Cpc**	**Weight**	**Thickness**	**Drapeability**
Raw Material (A)	F Value	0.24	20911.00	95.03	36.64	26.88
	P Value	0.9306	0.0459	<0.0001	0.0002	0.0005
	Contribution %	43653.00	46327.00	76.05	94.3	83.94
Tightness (B)	F Value	169000.00	98.14	17899.00	46844.00	43711.00
	P Value	0.0667	<0.0001	<0.0001	0.2681	0.0840
	Contribution %	35.90	83.98	43632.00	42401.00	35462.00
Raw Material xTightness	Contribution %	56.41	28216.00	32690.00	20149.00	43721.00
R^2		0.61	0.97	0.99	0.97	0.96

4.Conclusion

The drapability of 18 different samples was tested and the effects of raw material and tightness parameters were investigated. When the results of the study were analyzed, it was observed that the tightness had a significant effect on the fabric weight, but the effect on the drape could not be determined. Since the raw material factor had a significant effect on the structural properties of the fabrics, the drapability of the samples also changed depending on the raw material. All samples produced within the scope of the study are of cellulosic origin. In addition, they all turned into yarn and fabric under the same conditions. However, the results changed significantly. This clearly shows that chemical processes during wet spinning affect the softness and crystallinity of the fibers as well as their drapability. If all the production parameters are same the weight is decisive character on the drapability. To produce drape fabric, tightness, stitch density and the weight of the fabric should be high. For further studies other mechanical and comfort properties can be investigated by using different patterns.

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