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ABSTRACT

This study aimed to analyze the effect of tuck and miss stitch structures of regenerated cellulose fabrics like viscose, modal, Tencel, and bamboo. The fabrics were developed with the same stitch length and tightness factor and analyzed for their geometrical properties after dry and wet relaxation. The study results revealed that wet relaxation treatment showed more significant changes in the geometrical constant values (K) than the dry relaxation process. The highest wale density change was noted with cross miss stitch fabric and a maximum course density change noted for cross tuck samples after dry and wet relaxation. The differences in wale and course density were noted as statistically insignificant for the aforementioned structure after dry and wet relaxation ($p > 0.05$). However, in the case of stitch density, there is a statistical significance noted for the tested samples ($p < 0.05$). The maximum changes were noted in plain fabric followed by twill structure. The loop shape factor (Kr) value suggests higher distortion in the cross tuck fabric and after wet relaxation over dry relaxed samples followed by plain, twill, and miss stitch structures, and we also noted the relaxation process did not alter the loop shape factor (Kr) significantly between the dry and wet process ($p > 0.05$).

Keywords

regenerated cellulose yarn, knit structures, geometrical constant, dimensional changes, loop shape factor, relaxation

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Introduction

Knitting is the process of forming a fabric by inter looping yarn in a series of intermeshed loops using needles. Knitted fabrics are preferred in many types of clothing because of their extensibility, lightweight, warmth, wrinkle resistance, and ease of care.[1–4] The properties of a knitted structure are largely determined by the interdependence of each stitch to its neighbor stitch on either side, above and below it. As knit fabrics are produced on different machines with various conditions to produce different types of fabric, they bear different qualities.[5] Because of its higher extensibility and comfort aspects, the application requirements of knitted fabric have increased exponentially. The dimensional characteristic of knitted fabric is one of the essential properties that directly influence the wear comfort and aesthetic appearance of apparel. Hence, interest in knitted fabric dimensional parameters has attracted many researchers to analyze the geometrical properties and constants. Hurd F.T.I. and Doyle[6] reported the importance of the loop length, course, and wales density on the dimensional properties of a knit structure. A significant improvement in the research was obtained in a latter year by Munden,[7] who reported the dimensional constant (K) values of plain knit structures at dry relaxed states (DRS) and wet relaxed states (WRS). In their later research, they also evaluated the dimensional characteristics of nonhygroscopic yarns at dry and wet relaxation and found a 13 %–15 % difference in the constant.[8] Though many research works were performed in the later stage, like those by Leaf,[9] Postle,[10] and Gowers and Hurt,[11] Munden's model and his constant values are adapted most commonly by the subsequent researchers.

Single jersey knitted fabric properties, especially the dimensional and physical properties, are mainly influenced by the constituent fibers, yarn properties, knitting machine variables, processing, and finishing treatments. Because of the dimensional instability loop construction, single jersey knitted fabrics suffer from various forms of dimensional distortion. Kumar and Sampath[12] and Kumar, Sampath, and Vigneswaran[13] investigated the suitability of cotton sheath elastomeric core-spun yarn for circular knitting as an alternative for bare spandex feeding and the effect of loop length variables on the geometric properties of single jersey and double pique fabrics under different relaxation states. They reported that the course, stitch, and areal density have a significant increase between their fabric relaxation states. Gokarneshan et al.[14] investigated the dimensional properties of viscose, modal, and lyocell single jersey knitted fabrics while varying three levels of loop lengths under dry, wet, and fully relaxed conditions. They found the course and wale spacing values of lyocell fabrics to be lower than that of viscose and modal knitted fabrics. Lyocell fabrics exhibit greater areal density with decreasing loop length. Also, the *Ks* values of lyocell fabrics increase proportionately with an increase in the value of the tightness factor, compared with viscose and modal fabrics. Rahman and Smriti[15] studied the influence of different stitch lengths on the grams per square meter (GSM) of knit fabric with respect to the change of tuck loop percentage in the knit fabric structure. They observed an incremental increase of tuck loop percentage and descending of stitch length, a measurable increase in areal density. Khalil and Solaiman[16] investigated the influence of stitch length on dimensional properties like course per inch (CPI), wales per centimeter (WPI), and GSM and thickness and tightness factor, and also the change of physical properties such as air permeability and water absorbency, shrinkage, and spirality. Sakthivel and Anbumani[17] studied the dimensional properties of viscose, modal, and lyocell single jersey knitted fabrics with three levels of loop lengths that were studied under dry, wet, and full relaxation conditions. They found that the *ks* value of the lyocell fabrics increases proportionally with an increase in the value of tightness factor, compared to viscose and modal fabrics. Mikučionienė and Arbataitis[18] stated that the prediction of the physical properties of knits from new generation fibers following widely investigated common fibers is incorrect without appropriate experiments. Karthikeyan et al.[19] and Ramakrishnan, Umapathy, and Prakash[20] stated that the porosity of the knit is affected by the linear density of the yarn and the length of the loop. It was stated that knits from cotton and bamboo yarns give different permeability to air and water vapor and have different thermal properties.

Many researchers mention that geometrical and dimensional parameters such as loop shape factor, loop length, and fabric tightness factor are very important parameters. The number of courses per cm and the number of wales per cm has linear relations with the inverse of the loop length; the regression analysis has shown that the correlation of courses per cm with loop length is more significant. The yarn linear density is a predominant factor that affects the thickness of knitted fabric.[21,22] In this research, an effort is made to examine the geometric properties for a range of regenerated cellulose tubular single jersey knit fabric structures knitted with uniform machine parameters. Four types of regenerated cellulose hosiery yarns are procured, namely viscose, modal, Tencel, and bamboo, with similar linear density. Using that yarn four tubular knitted fabric structures are knitted, namely plain, cross tuck, cross miss, and twill, in the same circular multi-cam track single jersey knitting machines with uniform stitch length. Out of these four fabric structures plain is an all knit loop structure, cross tuck is a structure with a knit and tuck loop combination, cross miss is a structure with the knit stitch and miss, and the twill structure is produced with a combination of knit, tuck, and miss loops. The said fabric properties are measured in their DRS and WRS and compared for their dimensional changes in terms of geometrical constant values.

Materials and Methods

PROCUREMENT OF HOSIERY YARNS

Commercially available regenerated cellulose hosiery yarns such as viscose, modal, Tencel, and bamboo with a count of 19.68 Tex (30s Ne) are procured for the development of fabric samples.

KNITTING OF FABRIC SAMPLES

The procured four types of hosiery yarn are knitted into four different fabric samples, namely plain, cross tuck, cross miss, and twill, by using a multi-cam track circular jersey knitting machine as specified in **Table 1** with uniform stitch length. The fabric samples were developed as per the fabric sample plan given in **Table 2**.

DRY AND WET RELAXATION

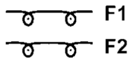
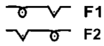
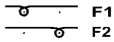
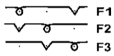
After knitting, all 16 gray cut samples are kept flat and tension-free for 48 hours under standard atmospheric conditions (21 ± 1°C temperature and RH 65 ± 2 %) in a conditioning chamber to reach their DRS.[23] Afterward,

TABLE 1

Circular knitting machine particulars

Serial Number	Machine Specification	
1.	Type of knitting machine	Circular
2.	Type of knitting	Weft knitting
3.	Make	Falmac, Singapore
4.	Diameter	20”
5.	Gage	24 E
6.	Number of feeders	60
7.	Feeder type	Positive storage feeder
8.	Number of needles	1,800
9.	Number of cam tracks	4

TABLE 2
Fabric sample plan

Serial Number	Fabric	Structure	Code	Symbolic Representation	Stitch Length in cm	Tightness Factor (K)
1.	Viscose	Plain	VPL		0.30	14.79
2.	Modal		MPL			
3.	Tencel		TPL			
4.	Bamboo		BPL			
5.	Viscose	Cross tuck	VCT			
6.	Modal		MCT			
7.	Tencel		TCT			
8.	Bamboo		BCT			
9.	Viscose	Cross miss	VCM			
10.	Modal		MCM			
11.	Tencel		TCM			
12.	Bamboo		BCM			
13.	Viscose	Twill	VTW			
14.	Modal		MTW			
15.	Tencel		TTW			
16.	Bamboo		BTW			

Note: B = bamboo; CM = cross miss; CT = cross tuck; M = modal; PL = plain jersey; T = Tencel; TW = twill; V = viscose.

the geometric properties, such as wale, course, stitch, and areal density, were measured and their respective constants, such as Kw, Kc, Ks, and Kc/Kw, are calculated for all the samples using the following formula[7]:

$$Ks = S \times l^2 \tag{1}$$

$$Kw = \text{Wales per inch} \times l \tag{2}$$

$$Kc = \text{Course per inch} \times l \tag{3}$$

$$Kr = \frac{Kc}{Kw} = \frac{\text{Course per inch}}{\text{Wales per inch}} \tag{4}$$

where S = stitch density and l = loop length.

A portion of dry relaxed fabric samples was immersed in a stainless steel water bath containing 0.5 gpl standard wetting agent with the water temperature maintained at about 37°C and allowed to relax with very mild agitation for 24 hours. Samples were then hydro-extracted for 1 minute and laid on a flat surface for 48 hours. Samples were brought back to the conditioning chamber with the standard atmospheric condition of 21 ± 1°C at an RH 65 ± 2 % and kept flat for 48 hours, free of tension to reach their WRS.[23]

After wet relaxation, the changes that occurred in the geometric properties of the fabric samples, such as wale, course, stitch, and areal density, are observed and recorded and their respective constants, such as Kw, Kc, Ks, and Kr or Kc/Kw, are also calculated and noted down. All the relaxation treatments are carried out as per the ASTM D1284-76, *Standard Test Methods for Relaxation and Consolidation Dimensional Changes of Stabilized Knit Wool Fabrics*, test procedure.

THE TESTING PROCEDURE OF GEOMETRIC PROPERTIES OF KNITTED FABRICS

The estimation of geometric properties of knitted fabrics, such as wale and course density (ASTM D3887-96 (2008), *Standard Specification for Tolerances for Knitted Fabrics*), loop length (ASTM D3887), areal density (ASTM D3776, *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric*), and thickness (ASTM

D1777-07, *Standard Test Method for Thickness of Textile Materials*) of the samples, are carried out for all the specimens in both DRS and WRS.

For the measurement of wale and course density a 1" by 1" square is marked on the samples in 10 different places apiece. After that, the wale density is counted with maximum attention with the help of a counting glass in all ten places of all the samples and noted. After that, the mean value of the wale density is estimated for each sample. In the plain jersey sample, the course density is measured carefully by using a thread magnifying glass in all ten places and noted. Afterward, the mean value of the count is estimated. But for the cross tuck, cross miss, and twill fabric samples the courses are found with the combination of knit and tuck, knit and miss and knit, and tuck and miss stitches, and hence direct counting of course density will not give accurate results. So, ten marked samples from these fabric samples are cut and unraveled course wise to estimate the course density and its mean value.

The stitch length is measured from unraveling 10 courses each with 100 wales (adjacent loops) and the total length of each course is measured after smoothly straightening the course. The average stitch length is calculated by using the simple formula, i.e., total length of 100 wales in cm/100 to obtain the length of one loop in cm from a course. In the same way, the loop length is obtained for all ten courses and the mean value is calculated for every sample.

The areal density of the knitted fabrics is measured by cutting the sample with an area of 100 cm^2 by using a standard circu-cutter. The cut sample is weighed in the electronic balance and the resultant value is multiplied by 100 to get the areal density in GSM. Thus, ten specimens are cut from each sample and the mean value is calculated.

Thickness is measured in ten different places of every specimen and noted down. From that, the mean is calculated for further analysis.

Statistical Analysis

To analyze the statistical significance between the knit structure and both the dry and wet relaxation treatment processes, a one-way analysis of variance (ANOVA) test was performed with a 95 % confident limit for individual parameters. The statistical analysis was performed using Minitab 19.1 (trial version) software.

Results and Discussion

Tables 3–6 express and help to compare the geometric properties of plain single jersey and derivative structures produced from viscose, modal, Tencel, and bamboo regenerated cellulose hosiery yarns.

TABLE 3

Comparison of geometric properties of viscose fabric structures

Relaxation State	Sample Code	'l' in cm	WD	CD	*Kw*	*Kc*	*S*	*Ks*	*K*	K_r = *Kc*/*Kw*	*GSM*	Thickness, mm
DRS	VPL	0.30	11.2	17.32	3.31	5.20	190.87	17.18	14.79	1.57	115	0.45
WRS			12.60	18.90	3.78	5.67	238.14	21.43		1.50	140	0.52
DRS	VCT		10.24	20.47	3.7	6.14	209.61	18.86		2.00	130	0.55
WRS			8.66	27.56	2.60	8.27	238.67	21.48		3.18	151	0.66
DRS	VCM		12.60	15.75	3.78	4.73	198.45	17.86		1.25	106	0.40
WRS			13.39	16.54	4.2	4.96	221.47	19.93		1.23	121	0.45
DRS	VTW		11.81	16.54	3.54	4.96	195.34	17.58		1.40	111	0.52
WRS			12.20	18.50	3.66	5.55	225.70	20.31		1.52	130	0.58

Note: CD = Course Density; cm = centimeter; CPI = course density measured in courses per centimeter; *GSM* = areal density in grams per meter; *K* = tightness factor; *Kc* = course constant; *Kc*/*Kw* = loop shape factor; *Ks* = stitch density constant; *Kw* = wales constant; *l* = stitch length; *S* = stitch density in stiches per cm^2; VCM = Viscose Cross Miss; VCT = Viscose Cross Tuck; VPL = Viscose Plain Jersey; VTW = Viscose Twill; WD = Wale Density; *WPI* = wale density measured in wales per centimeter.

TABLE 4
Comparison of geometric properties of modal fabric structures

Relaxation State	Sample Code	'l' in cm	WD	CD	*Kw*	*Kc*	*S*	*Ks*	*K*	K_r = *Kc*/*Kw*	*GSM*	Thickness, mm
DRS	MPL	0.30	10.63	17.72	3.19	5.32	188.36	16.95	14.79	1.67	118	0.46
WRS			12.60	19.29	3.78	5.79	243.5	21.87		1.53	142	0.54
DRS	MCT		10.24	21.26	3.7	6.38	225.99	20.34		2.00	134	0.56
WRS			9.84	26.77	2.95	8.3	263.42	23.71		2.72	153	0.66
DRS	MCM		12.20	15.35	3.66	4.61	187.27	16.85		1.26	105	0.41
WRS			12.60	16.93	3.78	5.8	213.32	19.20		1.34	117	0.44
DRS	MTW		11.42	17.32	3.43	5.20	197.79	17.80		1.52	119	0.51
WRS			12.60	18.11	3.78	5.43	228.19	20.54		1.44	133	0.58

Note: CD = Course Density and GSM = Grams per square meter; MPL = Modal Plain Jersey, MCT = Modal Cross Tuck, MCM = Modal Cross Miss, MTW = Modal Twill, WD = Wale Density.

TABLE 5
Comparison of geometric properties of Tencel fabric structures

Relaxation State	Sample Code	'l' in cm	WD	CD	*Kw*	*Kc*	*S*	*Ks*	*K*	K_r = *Kc*/*Kw*	*GSM*	Thickness, mm
DRS	TPL	0.30	11.2	18.2	3.31	5.41	198.58	17.87	14.79	1.63	118	0.44
WRS			12.60	18.90	3.78	5.67	238.14	21.43		1.50	137	0.52
DRS	TCT		10.24	21.26	3.7	6.38	217.70	19.59		2.8	133	0.57
WRS			9.45	25.59	2.84	7.68	241.83	21.76		2.70	156	0.65
DRS	TCM		12.59	16.93	3.78	5.8	213.15	15.57		1.34	107	0.41
WRS			13.39	18.11	4.2	5.43	242.49	18.57		1.35	118	0.46
DRS	TTW		11.41	17.72	3.42	5.32	202.19	18.20		1.56	117	0.50
WRS			12.60	18.90	3.78	5.67	238.14	21.00		1.50	134	0.57

Note: CD = Course Density and GSM = Grams per square meter; TPL = Tencel Plain Jersey, TCT = Tencel Cross Tuck, TCM = Tencel Cross Miss, TTW = Tencel Twill, WD = Wale Density.

TABLE 6
Comparison of geometric properties of bamboo fabric structures

Relaxation State	Sample Code	'l' in cm	WD	CD	*Kw*	*Kc*	*S*	*Ks*	*K*	$K_r = K_c/K_w$	*GSM*	Thickness, mm
DRS	BPL	0.30	10.62	16.93	3.19	5.8	179.80	16.18	14.79	1.59	120	0.45
WRS			12.60	18.50	3.78	5.55	233.10	20.98		1.47	145	0.53
DRS	BCT		9.84	19.69	2.95	5.91	193.75	21.72		2.00	139	0.56
WRS			9.10	25.59	2.73	7.68	232.87	24.98		2.81	161	0.67
DRS	BCM		12.99	16.54	3.90	4.96	214.85	19.34		1.27	104	0.41
WRS			14.17	18.11	4.25	5.43	256.62	23.10		1.28	116	0.44
DRS	BTW		11.2	18.11	3.31	5.43	199.57	19.5		1.64	120	0.52
WRS			11.81	18.50	3.54	5.55	218.49	19.66		1.57	138	0.60

Note: BPL = Bamboo Plain Jersey, BCT = Bamboo Cross Tuck, BCM = Bamboo Cross Miss, BTW = Bamboo Twill; CD = Course Density and GSM = Grams per square meter; WD = Wale Density.

WALE DENSITY GEOMETRICAL CONSTANT *Kw*

Except for the cross tuck fabrics, all other structures showed an increase in their wale density values between their dry and wet relaxation. The wale density increases from dry to wet relaxation of all types of plain fabric samples are seen to be greater than the cross miss and twill structures. It may be the outcome of minimal widthwise contraction of these samples during wet treatment. The highest wale density values are observed in all the cross miss fabric samples. From this, it is evident that the presence of miss stitches in a structure makes that fabric narrower and results in more wales in the given space than the structures knitted with other combinations. The lowest wale density values are recorded for the cross tuck fabric samples. In these samples, the fabrics are subjected to a widthwise enlargement due to the presence of tuck stitches and the net result is a drastic decrease in their wale density when compared to other samples taken for the observation. The presence of alternative tuck stitches with widened legs in each course of this structure would have pushed the adjacent knit loops widthwise and resulted in the widthwise expansion of the samples. This must be the reason behind the drastic reduction in their wale density. The remaining two samples, namely plain and twill, are recorded within wale density values, of which the twill fabrics have a slight edge over the plain.

Concerning the geometrical constant *Kw*, it can be noted that *Kw* is directly proportional to the product of the wales density value and stitch length. As the influencing factor, "l" stitch length is constant; the incremental increase in the wales density value is reflected in the *Kw* values. Though there is an incremental increase in the warp density in all the fabric after the relaxation process, the difference between the DRS and WRS samples are noted to be statistically insignificant ($p > 0.05$).

COURSE DENSITY AND CONSTANT *Kc*

All four types of fabric samples developed from each yarn have displayed a considerable increase in their course density values between their dry and wet relaxation processes. It may be due to the prominent lengthwise contraction that uniformly took place in all the samples during their wet treatment and further wet relaxation. Among the four structures, the cross tuck samples knitted with a knit and tuck stitch combination have exhibited the highest course density values in both DRS and WRS. They are also observed with the maximum level of raise in their course density between the consequent states of fabric relaxation. From the result, it is evident that the tuck stitches have caused the maximum lengthwise contraction and led to an increase in course density. The plain samples are noticed with higher course density next to cross tuck and followed by twill. But the incremental increase in course density between DRS and WRS is more for plain fabrics than the twill. It is now clear that the structure knitted with only knit loops has better lengthwise contraction during wet relaxation than a mixed structure with knit, tuck, and miss combinations. The cross miss samples knitted with knit and miss combinations have displayed the smallest course density values. The reason is nothing but the presence of miss stitches and it has caused the minimum lengthwise contraction of these fabrics during their relaxation. In the case of the geometrical constant *Kc*, as mentioned in the previous section, there was an incremental increase noted after the relaxation process.

The statistical analysis of course density variation of different samples between the dry and wet relaxation processes revealed that there is no significant difference in course density change. Statistically, the variation between the relaxation process was noted as insignificant ($p > 0.05$).

STITCH DENSITY AND CONSTANT *Ks*

All the fabric samples have shown significant changes in their stitch density values between their DRS and WRS. The main reason for this outcome is the uniform increase in the wale density except for the cross tuck and course density of all these samples in between their DRS and WRS. The fall in the wale density of cross tuck samples between their subsequent fabric relaxation states is compensated with the remarkable increase in their course density values. Since stitch density is directly proportional to course density, the results here are very much similar and comparable to the results of course density.

"*Ks*" values are a representation of the area occupied by the loops in the fabric plane. For the *Ks* value, the incremental increase in the stitch density influenced much in all the types of fabrics. Out of both methods, the *Ks* values are noted higher in the case of wet relaxed samples than the dry relaxed sample. This is mainly associated with the higher changes in the wales and course density of the knit structures after wet relaxation than the dry relaxation. As the loop length is kept constant in all the samples, along with the tightness factor, it is expected that the dimensional change is due to the relaxation. Munden[7] reported that at a completely relaxed state, the *Ks* value is constant and independent of stitch length.

Statistical analysis results divulged that the changes in the stitch density between the DRS and WRS were noted as significant between the different structure and fiber types used ($p < 0.05$). It is important to mention that though the course and wales density changes are insignificant ($p > 0.05$) statistically, the combined effect of those changes was noted as significant between the dry and wet relaxation processes.

AREAL DENSITY

The areal density of the knitted fabrics depends on their stitch length, tightness factor, machine gage, yarn linear density, fabric thickness, etc. But all the fabric samples are constructed with similar stitch length, tightness factor, machine gage, and yarn linear density for this research work to understand the impact of stitch combinations in the fabric properties. Out of the four samples from each yarn, the cross tuck samples have shown the highest areal density values in both their DRS and WRS. It was the accumulation of tuck stitches that led to a resultant increase in the mass of the cross tuck fabrics. The plain and twill samples of all the yarns are found with the next higher areal density values. All the plain and twill fabrics show more or less the similar areal density in their DRS. But plain fabrics have displayed higher area mass than twill after WRS. This effect may be due to the higher lengthwise contraction of plain samples and the resultant increase in their stitch density. Even though the thickness of twill samples is found to be higher than the plain in both DRS and WRS, it has not played any role in determining the mass of these samples. Among them all, cross miss samples were found with the least areal density values in their DRS and WRS, because the miss stitches made these samples flimsy and caused a significant reduction in the mass of these samples. Selected sets of samples have shown a substantial increase in their areal density between dry and wet relaxation. It is mainly because of the noteworthy incremental increase in the course density of these samples between their dry and wet relaxation.

In the case of areal density, statistical significance was noted between the dry and wet relaxed fabric samples only in the case of viscose fiber ($p = 0.05$). In the case of other fibers like modal, Tencel, and bamboo, the density differences between the dry and wet relaxation state were noted to be statistically insignificant ($p > 0.05$).

FABRIC THICKNESS

The cross tuck fabric samples have displayed the uppermost thickness values after their dry and wet relaxation. The tuck stitches in these samples may be the root cause of this effect. The presence of tuck stitches along with knitting and miss stitches have made the twill samples the second best. The plain fabrics have shown better thickness values than cross miss. The cross miss fabric samples are observed with the smallest thickness values because of the flimsy nature of these samples. Selected samples have shown a significant incremental increase in their thickness between and after dry and wet relaxation. However, a higher thickness was noted after wet relaxation compared to dry relaxation. Although the twill samples have higher thickness than the plain samples they have displayed more or less the same GSM in DRS and lesser GSM in WRS. It is evident from the comparison of thickness and areal density values of plain and twill fabrics. The fabric samples such as cross tuck and twill have more thickness because of the presence of tuck stitches and the sample like cross miss has lesser thickness due to miss stitches. All the fabric samples have exhibited a remarkable incremental increase in their thickness values during the successive fabric relaxation states. The statistical evaluation results did not show any significant difference in the thickness of the material between the dry and wet relaxation process ($p > 0.05$).

LOOP SHAPE FACTOR (*Kr* OR *Kc*/*Kw*)

The *Kr* or *Kc*/*Kw* value is defined as a loop shape factor. The loop shape factor represents the shape of the loop after different relaxation conditions. The results represented in Tables 3–6 showed the higher loop shape factor values for the cross tuck samples. This indicates that the cross tuck structure samples are slacker in structure than the other fabric. Out of the two relaxation techniques, a higher loop shape factor value was noted for the wet relaxation samples. Next to the cross tuck sample, the plain structure showed a higher loop shape factor followed by the twill and cross miss structure. However, the statistical results showed insignificant changes in the case of loop shape factor between the DRS and WRS of the tested samples ($p > 0.05$).

Conclusions

The research evaluated the impact of dry and wet relaxation on the dimensional and geometrical changes of plain, twill, cross tuck, and miss stitch structures of regenerated cellulose fabrics. The results showed that cross miss fabric samples, knitted with an equal number of miss and knit stitches, caused more widthwise fabric contraction and displayed the maximum wale density. In the case of a cross tuck and knit structure the trend is noted exactly opposite to that of miss and knit stitches. The relaxed fabric showed a minimum wale density due to the widthwise fabric enlargement caused by the tuck stitches. Plain, twill, and cross miss fabric structures have exhibited a notable increase in their wale density values between dry and wet relaxation. The reverse effect with the cross tuck fabrics is mainly attributed to the presence of tuck stitches. However, the cross tuck fabric samples developed with the knit and tuck stitch combination have exhibited the highest course density values after both dry and wet relaxation.

Next to the cross tuck stitches, the plain fabric samples are noticed with higher course density, and it is followed by twill samples. But the incremental increase in course density between dry and wet relaxation is more for plain fabrics than the twill. These findings confirmed that the knit structure with full loops had more lengthwise contraction during wet treatment. This confirms the wet relaxation method provided higher relaxation to the selected fabric sample. Statistical results were also supported in that the changes were higher in wet relaxation than the dry relaxation method. Cross miss fabric samples showed a lesser variation in course density values among all the samples after the wet and dry relaxation processes. The presence of miss stitches in these samples has triggered the minimum lengthwise contraction in these fabrics during relaxation. The results showed a clear change in the dimensional property of selected structure through an incremental increase in their course, stitch, and areal density values between their wet and dry relaxation processes. The finding of the research gives an idea about structural and dimensional changes in the selected knit structure with the relaxation process.

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