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Influence of Knit and Miss Stitches on Air and Water Vapour Permeability of Flat Knitted Rib Fabrics

Ribana Kumaşların Hava ve Su Buharı Geçirgenliklerine İlmek ve Atlama Kombinasyonların Etkisi

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INFLUENCE OF KNIT AND MISS STITCHES ON AIR AND WATER VAPOUR PERMEABILITY OF FLAT KNITTED RIB FABRICS

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ABSTRACT: The double jersey flat knitted rib fabrics were produced and used for the investigation. During flat knitting operation, the percentage contribution of knit (K) and miss (M) stitches in the fabric structure has varied to study the air and water vapour permeability properties of the fabric. The variation in the fabric is in three levels such as 100K: 0M, 87.5K: 12.5M and 83K: 17M. One way analysis of variance is conducted to test the significance of test results. In order to confirm the significance of result, Tukey's least significant test also used for this study. Based on the tests conducted in this study, the contribution of knit and miss stitches in the fabric influences the permeability properties of knit fabric significantly.

Keywords: Flat knitting, knit stitch, miss stitch, air permeability, water vapour permeability.

RİBANA KUMAŞLARIN HAVA VE SU BUHARI GEÇİRGENLİKLERİNE İLMEK VE ATLAMA KOMBİNASYONLARIN ETKİSİ

ÖZET: Bu çalışmada ribana yapısında örme kumaşlar kullanılarak dolu iğne ve boş iğne kombinasyonları ile hava ve su buharı geçirgenlikleri üzerine ribana kumaş yapısının etkileri incelenmiştir. Tek yönlü varyans analizi yapılarak Tukey testi kullanılarak ribana yapısının oluşumunda dolu/boş iğne oranının hava ve su buharı geçirgenliği açısından önemli olduğu belirlenmiştir.

Anahtar Kelimeler: Düz örme, ilmek, atlama, hava geçirgenliği, su buharı geçirgenliği

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1. INTRODUCTION

The air and moisture transport properties of the textile structure have great influence on balancing of human body. The human body produces energy and dissipates to maintain the thermal equilibrium. The wearer skin dissipates the moisture in the form of sensible and insensible perspiration. The comfortable sensation is based on removal of perspiration through the fabric by water vapour and air permeability. The air permeability of the fabric is how well the fabric allows to pass the air through the fabric. It is happened in the fabric in any one of the following, i) the air can pass through the material, it is based on the characteristics of the yarn. ii) The air can pass through the fabric through the pores it is based on the structure of the fabric. So, the yarn, fabric geometric characteristics and finishing treatment are the factors influencing the air permeability of the fabric. Many researchers are done their study in this field. The surface area of fiber increases the resistance to air flow also increases [1]. The porosity of knit fabric is increased with increases in loop length, but it is not a common rate for comparison of air permeability of the fabric produced with variable knit pattern. The area linear filling rate can be predicted for the comparison of variable knit pattern fabric [2]. The pore characteristics such as pore dimension and its distribution in the knit fabric determine the airflow of the textile fabrics [3]. The porosity of the knit fabrics directly related with the structure and the type of yarn [4]. The thickness of the fabric also influences the air permeability of the fabrics. The author concluded with there is a significant influence on surface porosity with air permeability of plain double layer and lining knit fabrics [5].Depending on the air permeability of the fabric the water vapour permeability of the fabric varied. The structure of the knitted pattern determines the amount of air trapped, this is based on the order of loops arranged in the fabric pattern [6]. The clothing performance is maintained by the water vapour permeability of the fabric. The water vapour permeability indicates the quantity of water vapour that has been moved through a unit area of the fabric in a certain point in time as a result of the pressure gradient between the two sides of the sample [7]. There are four mechanisms are involved for the permeability of water vapour through the textile layers. The author Brojeswari Das et al.,[8] pointed the mechanisms, such as a) diffusion of the water vapour through the layers. b) absorption, transmission and desorption of the water vapour by the fibres. c) adsorption and migration of the water vapour along the fibre surface. and d) transmission of water vapour by forced convection. The wicking phenomena of the fiber also studied by the researchers based on their arrangements in the structure [9]. The structure of the fabric is important factor that influence the permeability properties of the textile fabrics. The fabric produced with float stitches make the fabric flimsy or less rigid structure compared to other combination fabrics. The yarn consumption required for miss/float loop formation also less. So the fabric has less extensible and narrower [10-12].

The aim of this study is to investigate the influence of knit and miss stitches contribution in the knitting structure on air permeability and the water vapour permeability of flat knitted rib fabrics. One way analysis of variance (ANOVA) is conducted to test the significance of test results. In order to confirm the significance of result, Tukey's least significant test also used for this study.

2. MATERIALS AND METHODS

The flat knitted rib fabrics were produced using two combined yarn of (30^sNe) 100% cotton ring spun yarn having 2200 count strength product (CSP). The opposite V bed flat knitting machine has used for the fabric production. The knitting machine particular is shown in Table 1. By the contribution of knit and miss/float stitches in the structure, three rib fabrics were produced is shown in Table 2. The percentage contribution of stitches was selected based on the equation (1) and equation (2). The difference in percentage of knit and miss stitches between samples are also calculated based on the equation (3) and shown in Table 2. The needle representations of the rib fabrics are shown in Figure.1. The highlighted view in the needle diagrams represents the repeat of the particular structure say S1, S2 and S3.

$$\text{Percentage contribution of knit stitches} = \frac{(K_F+K_B)}{K_{FB}} \times 100 \qquad (1)$$

Where
$K_F = Number\ of\ Knit\ stitch\ needles\ in\ front\ needle\ bed$
$K_B = Number\ of\ Knit\ stitch\ needles\ in\ back\ needle\ bed$
$K_{FB} = Total\ number\ of\ needles\ in\ front\ and\ back\ needle\ bed$

$$\text{Percentage contribution of miss stitches} = \frac{(M_F+M_B)}{M_{FB}} \times 100 \qquad (2)$$

Where
$M_F = Number\ of\ miss\ stitch\ needles\ in\ front\ needle\ bed$
$M_B = Number\ of\ miss\ stitch\ needles\ in\ back\ needle\ bed$
$M_{FB} = Total\ number\ of\ needles\ in\ front\ and\ back\ needle\ bed$

$$\text{Percentage difference of knit and/or miss stitches between samples} = \frac{(Difference\ between\ Sample\ 1\ M_{FB}\ and\ Sample\ 2\ M_{FB})}{Sample\ 1\ M_{FB} + Sample\ 2\ M_{FB}} \times 100 \qquad (3)$$

Where
$M_{FB} = Total\ number\ of\ needles\ in\ front\ and\ back\ needle\ bed$

Table1. Flat knitting machine details

Knitting M/c	Flat Knitting
Make	M/s APEX Engineering Works, India
Model	Anmol- 3437
No. of Needles	1232
Width of the Machine	44 inch
M/c Gauge	14
M/c Speed (rpm)	40 rpm

Table 2. Percentage contribution of knit and miss stitches

Sample Code	Knit Stitches (%)	Miss Stitches (%)	% difference between samples		
				Knit Stitches	Miss Stitches
S1	100	0	**S1-S2**	6.66	100
S2	87.5	12.5	**S2-S3**	2.44	14.3
S3	83	17	**S1-S3**	9.1	100

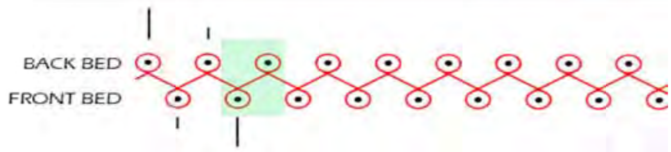
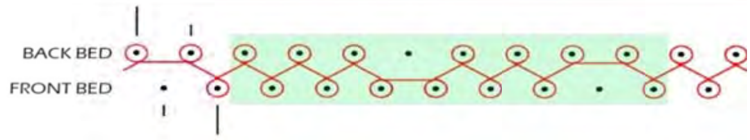
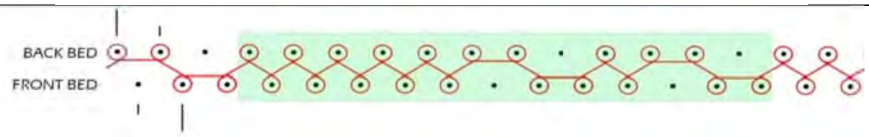
Sample Code	Needle Representation
S1	
S2	
S3	

Figure 1. Needle representation of flat knitted rib fabrics

3. TESTING

The permeability characters of the knitted fabric, namely air and moisture vapour permeability tests were conducted in this study. The produced rib fabrics were kept under standard relaxation process and carried out the following test. The knitted fabric parameters are given in Table 3.

The course and wale density of the samples in face and back were calculated individually in the direction of the length and width of the knit fabric. The average density per square centimeter was taken for the discussion. The stitch length/loop length was measured by using the equation (4), the average loop length (cm) was taken and reported in Table 3.

$$\text{Stitch length/loop length in cm} = \frac{L_T}{N} \quad (4)$$

Where

$L_T = Extendted\ Length\ of\ unraveled\ yarn\ in\ centimeter$
$N = Number\ of\ loops\ unraveled$

The tightness of knits was characterized by the tightness factor. It is known that, is a ratio of the area covered by the yarns in one loop to the area occupied by the loop. It is also an indication of the relative looseness or tightness of the knitted structure. The tightness factor of the rib fabrics were shown in Table 3. For determination of TF the equation (5) was used.

$$\text{Tightness Factor (TF)} = \frac{\sqrt{T}}{l} \quad (5)$$

Where

$T = Yarn\ linear\ density\ in\ Tex$
$l = Fabric\ loop\ length\ in\ centimeter$

3.1 Water Vapour Permeability

The evaporative dish method based on the British Standard, BS 7209 was used to determine the water vapour permeability (MVP) of rib fabrics [13]. As per the standard the test fabric is sealed over the open mouth of a disc, which contains water and the setup is placed in a controlled atmosphere of 20°C and 65% relative humidity. The weighing of the assembly (disc and rib fabric) was made successively to determine water vapour permeability of rib knit fabrics. The MVP in g/m^2/24hours is calculated as per equation (6) as given below.

$$\text{Water vapour Permeability (WVP)} = \frac{24\,M}{At} \quad (6)$$

Where

$M = Loss\ in\ mass\ of\ the\ assembly\ over\ the\ time\ period\ (t) in\ grams$
$A = Time\ between\ successive\ weighing\ of\ hte\ assembly\ in\ hours$
$t = Area\ of\ the\ exposed\ test\ fabric\ (0.0054\ m^2)$

3.2 Air Permeability

The measurement of the air permeability is the rate of air flow passing perpendicularly through a known area under a prescribed air pressure differential between the two surfaces of a material of textile fabrics [7]. The air resistance values of the rib knitted fabrics were measured individually by using Kawabata evaluation system (KES-FB-AP1 Katotech co, Ltd.,) under automatic air permeability tester. The instrument sends air at constant flow rate to the fabric through the movement of its plunger and cylinder piston. The discharged or sucked air through the fabric is detected and ventilation resistance of the fabric (R) is calculated. The air resistance value of KES is converted into air permeability of the rib knitted fabric using the equation (14).

$$\text{Air permeability } (Cm^3/Cm^2/S) = \frac{124.55}{(R \times 1000 \times 10^{-2})} \qquad (7)$$

Where

$R = Air\ resistant\ value\ (Kpa.S/m)$

4. RESULTS

The air and water vapour permeability of the rib knitted fabrics were done based on the standard methods. The ten readings for each test results were discussed with one way analysis of variance (ANOVA) and Tukey's least significant analysis [15].

4.1 Air Permeability

The air permeability of the flat knitted rib fabrics with varying the knit and miss stitches contribution in structures are shown in Figure.2 and Table 4. The yarn diameter, knitting structure, stitch density and yarn linear density are the important factors affecting the pore size of knitted fabrics. The air permeability value of the sample is higher for S1 (100K0M) followed by S2(87.5K12.5M) and S3(83K17M) . The linear trend has observed when decreases the knit stitch contribution by increasing the miss/float stitch contribution in the fabric.

The analysis of variance (ANOVA) confirmed that there is a significant difference in the test results obtained from S1, S2 and S3 rib knitted fabrics. The Table 4 shows the F-value is greater than the F-critical value (8.94>3.35). In order to confirm the significant, the Tukey's least significant test also analyzed. The difference between the air permeability results of the paired knit samples S1&S2, S2&S3 and S1&S3 are 30.84, 0.188 & 30.66 respectively. The difference in air permeability of S1&S2 and S1&S3 are greater than q = 20.82 as table value. It shows the two structures (S1:100K0M and S3:83K17M) are highly significant in air permeability of the rib knitted fabric.

The miss/float stitches in a repeat of S2 fabric increases from S1 fabric, the wales in the fabric become closer which increases the density and make the wales closer linear side of the miss stitch. The tightness of the wale is based on the distribution ratio of the miss stitches and knit stitches in front and back of the rib fabric. The miss/float stitch in a fabric reduces air spaces in between the loops, which increases the air resistance. So the air permeability of the fabric reduced.

In S3 fabric the percentage contribution of miss stitches is higher than S2 fabric (14.3%). The higher percentage of miss stitches in the fabric make the fabric thinner around the miss stitches places. So the air can pass through the fabric with less resistance like single jersey fabric. Because of this the S2 and S3 fabric gets same air permeability. This can be varied by altering the distribution of miss stitches in between the knit stitches without varying the percentage contribution.

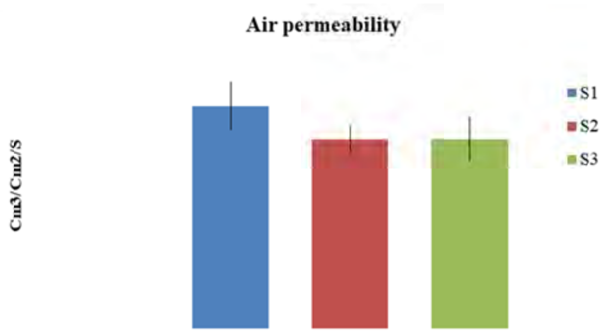


Figure 2. Air permeability property of Rib fabrics

Table 3. Rib Fabric Characteristics

Sample Code	Wale density (W/Cm)	course density (C/Cm)	Loop Length (Cm)	Stitch Density (Stitches/ Sq.Cm)	Tightness Factor ($Tex^{1/2}.cm^{-1}$)	Areal Density (gsm)	Thickness (mm)
S1	14.76	8.74	0.53	118.37	11.82	305.45	1.50
S2	14.61	8.86	0.49	129.39	12.78	309.80	1.50
S3	13.35	9.61	0.49	124.05	12.75	311.50	1.50

4.2 Water Vapour Permeability

The water vapour permeability (WVP) of the rib knitted fabric as S1, S2 and S3 is shown in Fig.3 and Table 5 . The WVP of flat knitted fabric is based on how the yarns of loops are bends to form the structure. ie. the combination percentage of knit stitches and miss stitches in a structure. The test result shows increases WVP due to increases the number of knit stitch forming needles as compared to increases the idle needles (miss stitch) in a machine.

The WVP value is high for S1 followed by S3 and S2. In S2 fabric increases the miss stitches to 12.5% the wales in the fabric become closer leads decreases the air spaces between the loops and increases the resistance for WVP. So the water vapour can pass through the fibers more. On the other hand, beyond increases of miss stitches (17% in S3) based on closer distribution of miss stitches in the structure increases the air spaces. This creates the net capillary force which increases the diffusion of water vapour. So the WVP of S3 fabric is higher as compared to S2 rib knit fabric. Because the diffusion coefficient of water vapour through the air is higher (0.239 cm^2/sec) as compare to cotton (10^{-7} cm^2/s)[15].

Anova shows significant difference in between the water vapour permeability of the flat knitted fabrics produced with varying knit and miss stitches in various structures. [F (2, 27) > *F critical*] is shown in Table 5. The Tukey's least significant test also confirmed that there are significant differences between the WVP of double layer knit structures S1 & S2, S2 & S3 and S1 & S3. The table value for q is 190.29 and the mean differences between the above paired samples are 1561.77, 304.05 & 1257.72. The mean values are greater than table value; this shows the significant differences at 95% level.

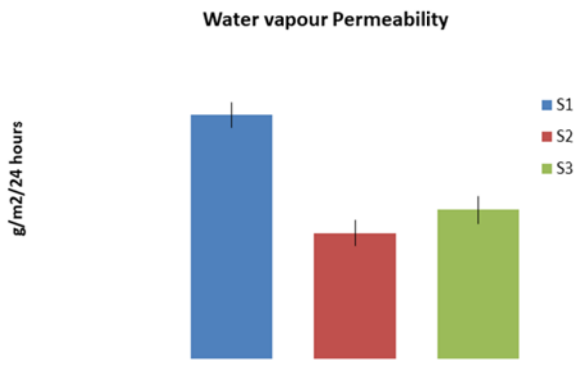


Figure 3. Water vapour permeability property of Rib fabrics

5. CONCLUSION

In this study, the flat knitted rib fabrics produced with percentage contribution of knit and miss stitches are influences the air and water vapour permeability of the fabrics. By increasing the knit stitch percentage in the structure make even spacing of wales in a fabric, which increases the air permeability of the fabric. By increasing optimum of miss/float stitches in the fabric (S2) increases the closeness of wales which reduces the air permeability. The contribution of miss/float stitches increases further in a fabric (S3) based on distribution of miss stitches fabric become more permeable, so significant increases in air permeability of the fabric and water vapour diffusion through net capillary force. The tightness of the wales in two side of the fabric is based on the distribution of miss/float wales in the fabric. For distinctive knitted fabric applications, by the selection of optimum contribution of knit and miss stitches in a fabric design can be useful for foundation structure for breathable stretch fabric.

Table 4. Air Permeability and Anova Analysis of Rib Fabrics

	AIR PERMEABILITY ($CM^3/CM^2/S$)					
	S1		**S2**		**S3**	
Average	207.9815		177.1333		177.3214	
Variance	494.231		140.303		423.815	
	ANOVA SINGLE FACTOR DATA ANALYSIS					
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	6305.61	2	3152.81	8.936967	0.001051	3.35
Within Groups	9525.14	27	352.78			

Table 5. Water Vapour Permeability and Anova Analysis of Rib Fabrics

	WATER VAPOUR PERMEABILITY (G/M^2/24 HOURS)					
	S1		**S2**		**S3**	
Average	6229.631		4667.855		4971.91	
Variance	28711.89		28322.78		31347.49	
	ANOVA SINGLE FACTOR DATA ANALYSIS					
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	13711528	2	6855764	232.7086	9.48E-18	3.35
Within Groups	795439.4	27	29460.72			

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