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Research Article

Investigate the Relation among Thickness, Relative Porosity and Air Permeability of different types of Knitted Fabrics

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Abstract

Total different four types of different knitted fabrics (single jersey, single lacoste, rib and 2 thread fleece fabric) with three different GSM for each were taken for observing their thickness, relative porosity and air permeability. Relative porosity was measured by suitable equation (discussed on method) and thicknesses along with air permeability were generated by AMES thickness gauge and MAC air permeability tester respectively. From the details analysis it was explored that with the decrease of stitch length and count fabric thickness increases and the reason is decrease of stitch length and count causes GSM increment. Another observation confirms the relative porosity and air permeability reduction with the decrease of stitch length and yarn count for every fabric. Most interesting result was seen for relative porosity and air permeability which is single lacoste & two thread fleece fabric have lower relative porosity value than single jersey fabric but shows higher air permeability as it is known that air permeability and relative porosity is proportional to each other. All these happened for the presence of tuck loop in single lacoste and two thread fleece fabrics which cause irregularity in density of fabric which is not considered in the relative porosity equation. So it can be declared that relative porosity equation is not applicable for those knitted fabrics where tuck in existing.

Keywords: *Thickness, Air permeability, relative porosity.*

Introduction

Knitted fabrics are always popular for their excellent comfort. They do have high extensibility and flexibility under low load and easily fit on any part it is pulled on to. Applying the interloping technology of yarns knit fabrics are constructed, and in this manner a large percentage of the total volume of a fabric is, usually, airspace. And a number of significant fabric properties like warmth and protection against wind, rain in clothing, and efficiency of filtration in industrial cloths are highly influenced by the distribution of this airspace (Karaguzel 2004).

Also, some physical properties for example, the moisture absorbency, the bulk density, the mass transfer and the thermal conductivity will be influenced by the air permeability and the porosity of a knitted structure (Tugrul Ogulata 2001).

A technique of forming fabric by interloping of yarn in a series of connecting loops using needles is knitting. For its outstanding comfort qualities it has been preferred in many types of outfits. In addition with this comfort quality conveyed by the extensible looped construction, knits also provide lightweight, warmth, wrinkle resistance, and ease of care. (Tugrul Ogulata 2009).

For this looped structure, along with its stretchable and extensible construction, such knitted fabrics have a more openly character if compared to other textile constructions like woven and braided. (Tugrul Ogulata 2001).

Air permeability can be defined as the volume of air (in liters) passed through 100 cm2 (10 cm × 10 cm) of the fabric in a minute at a pressure difference of 10 mm head of water (TS 391 EN ISO 9237 1999).

Regarding the comfort of a fabric air permeability is an important factor, as it plays a role of transporting moisture vapor to the outside atmosphere from the skin. The assumption is like that, the vapor travels mainly through the free spaces of fabric by diffusion in air from one side of the fabric to the other. (Karaguzel 2004).

Air permeability is a fabric property which is often used as a parameter of evaluating and comparing the 'breathability' -which can be defined as the ability of a fabric to allow moisture vapor to be transmitted through the material of different fabrics (coated and uncoated) (2001.2.34-1990 n.d.).

Most of the previous studies investigated the relationship between the air permeability and structural characteristics of plain knitted fabrics.

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It has been observed that for dry relaxed cotton 1 × 1 rib knitted fabrics, the thermal retaining property decreases with the increase of stitch length, porosity and air permeability. (Oinuma 1990). The air permeability of cotton/ spandex single jersey fabrics and 100% cotton knitted fabric alone within their dimensional and physical properties were investgated. It was proved that the air permeability of fabrics containing spandex was lower than cotton knitted fabric. (Marmaralı 2003).

The pore size and pore volume for plain knitted fabrics were measured in an experiment with the image analysis and fluid extrusion procedures and a remarkable difference was found between the estimated and measured values. (Karaguzel 2004).

An index referred as impact permeability (IP) of different woven fabric was measured with respect their flow properties and used it in finding the structural properties of that fabric (Tokarska 2008).

It was also noticed that air permeability and heat transfer through cellulose textile fabrics is closely related to both the capillary structure and surface characteristics of yarns. (Snezana Stankovic 2008).

Fabric porosity depends on different fabric parameters and relaxation progression. A theoretical model was developed to predict the porosity of a knitted structure depending on geometrical parameter. (Tilak Dias 2008).

An investigation on air permeability of cotton knitted fabrics was carried out to obtain regression equation which was used to predict air permeability before manufacturing the fabrics, depending on some fabric properties. (Tugrul Ogulata 2009).

The surface porosity on the basis of computer image analysis of knitted fabrics for plain double-layered and lining knitted fabrics was also evaluated. It was found that air permeability, contrary to water vapor permeability, is a function of the thickness and surface porosity of knitted fabrics. (Bożena Wilbik-Hałgas 2006)

Materials and method

To carry out the experiment twelve samples of single jersey, single lacoste, rib, two thread fleece of different GSM were taken to thickness, relative porosity & air permeability. Thickness was tested by AMES thickness gauge, relative porosity was calculated by equation

$$\delta = \left(1 - \frac{W}{\rho - t}\right) X100\% \quad (1)$$

Where W= fabric weight in g/cm2, ρ is the fabric density in gm/cm2, t is fabric thickness in cm and δ is relative porosity (ISO 1996). Air permeability (cc/cm2/s) was tested by following ASTM D737-96 method equipped with MAC air permeability tester. After getting all the reports the following table was generated:

Table 1: GSM, thickness, relative porosity and air permeability of different knit fabrics

Fabric type	Count & stitch length	GSM	Thickness (inch)	relative porosity	Air permeability (cc/cm2/s)
S/J	26s & 2.9mm	160	0.033	85.06	163.88
	26s & 2.8mm	170	0.034	84.61	156.94
	26s & 2.65mm	190	0.038	81.06	155.12
S/L	26s & 2.75mm	180	0.036	82.92	167.361
	26s & 2.65mm	200	0.041	77.25	163.888
	26s & 2.55mm	210	0.042	76.71	163.742
Rib	28s+20D/LY& 2.85mm	200	0.043	72.94	160.416
	28s+20D/Ly& 2.65mm	220	0.046	69.21	156.944
	34s+20D/Ly& 2.55mm	280	0.048	74.01	156.944
2 thread fleece	34s+34s& 2.80+1.25mm	180	0.042	70.99	163.888
	34s+34s& 2.75+1.25mm	200	0.044	70.24	156.944
	26s+26s& 2.85+1.35mm	220	0.045	71.86	167.361

Results and discussion

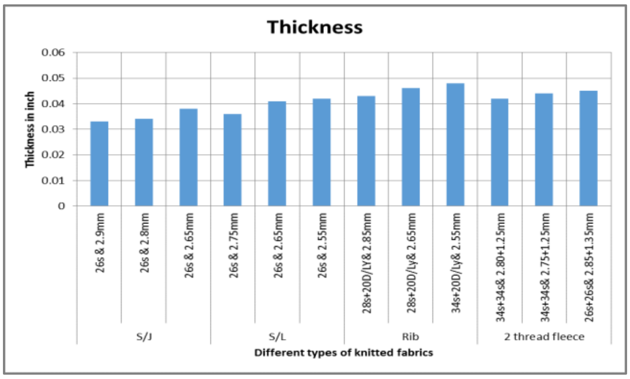

Fig 1: Thickness Vs different fabric structures

From table 1 and figure 1 it was observed that the structure of knit fabric has prominent effect on the thickness of the fabric. In case of single jersey and single lacoste fabric the thickness was increased (0.033-0.038 inch and 0.036-0.042 inch) with the decrease of stitch length (2.9-2.65 and 2.75-2.55) for same count (26s). The presences of tuck stitch within the single lactose fabric make it thicker than the plain single jersey fabric. The thickness of double jersey fabric and 2 two thread fleece fabrics (0.043-0.048 inch) are considerably higher than the single jersey and single lactose fabric (0.033-0.042 inch).

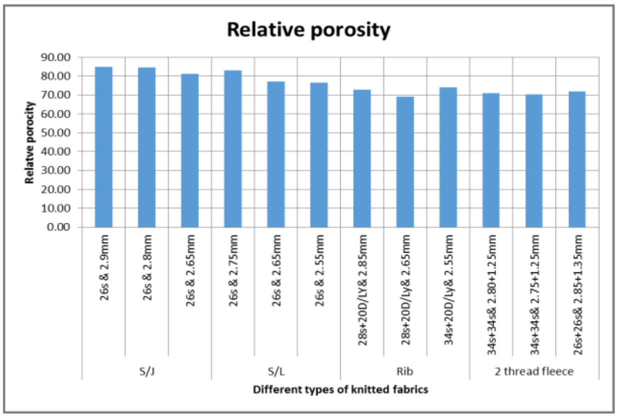

Fig 2: Relative porosity Vs different fabric structures

From table 1 and figure 2, the relative porosity of different knitted fabrics was evaluated. The loop length of fabric and yarn count is the main factors affecting the porosity of fabric. In case of S/J fabric, maximum porosity reached to a value of 85.06% for the highest stitch length used (2.9 mm) and gradually decreased to 81.06% for 2.65 mm for a fixed yarn count (26s) applied. The S/L fabric also indicated the same profile having the porosity of 82.92% and 76.71% with the largest loop length of 2.75 mm and 2.55 mm respectively. Air porosity of the Rib structure increased with the longer stitch length for same yarn count used. Also as the yarn gets coarser and the pores between loops get smaller, the air permeability decreased accordingly. Pore size values were also affected in the same way as in Rib for two thread fleece fabric.

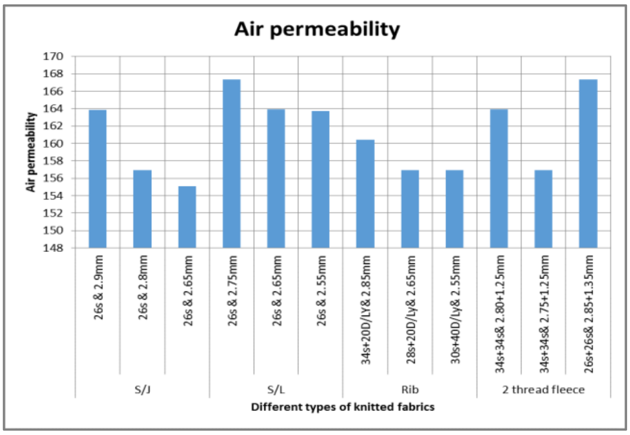

Fig 3: Air permeability Vs different fabric types

Table 1 and Figure 3 explores that fabric with high stitch length exhibit higher air permeability because of rising loop length produced a slacker surface on the fabric. It was also observed that single lacoste fabrics (163.742-167.361) are more air permeable than single jersey (155.12-163.88) due to the presence of tuck loop which create more open space on the fabric. In case of double jersey and two thread fleece fabric, the former shows lower air permeability values because of its compact structure. The maximum values are shown in two thread fleece (156.94-167.361) and single lacoste fabric (163.742-167.361).

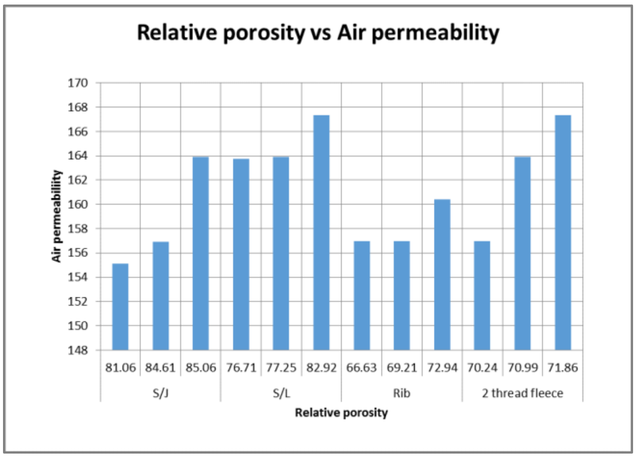

Fig 4: Air permeability Vs relative porosity

Porosity and permeability are strongly connected with each other. Normally the fabric with high porosity shows higher air permeability value. But interestingly in case of single lacoste fabric (163.742-167.361) and 2 thread fleece fabric (156.94-167.361) , higher air permeability was observed though they have lower relative porosity (76.71-82.92 for single lacoste, 70.24-71.86 for 2 thread fleece) than single jersey (81.06-85.06) and rib fabric (69.21-74.01) (figure: 4 and table 1). Single lacoste and 2 thread fleece fabric contain tuck loop which causes increase in thickness, porosity and air permeability whereas the equation (i) settles that thickness and porosity are inversely proportional. As it is known that presence of tuck loop causes irregularity in fabric density, figure- 1 approves that fabric structure also affects the relative porosity and air permeability along with yarn count and stitch length.

Conclusion

In this research, it is found that, fabric structure (presence of tuck loops) as well as stitch length has significant effects on the thickness of fabric although the yarn count remains unchanged. For these reasons, double jersey, single lacoste and fleece fabrics represent higher thickness than the plain single jersey fabric in case of same yarn count.

Moreover, beyond the regular expectation, it is obtained that, fabric thickness is certainly, inversely proportional to the fabric porosity. That is why, single lacoste and two thread fabric shows higher air permeability than plain jersey because of having tuck loops and these make the fabric surface irregular to allow more air.

Furthermore, the fabric structure has influenced the relative porosity and air permeability together with the yarn count and stitch length.

Likewise, along with the yarn count, ascending stitch length and the presence of tuck loop is also responsible of higher air permeability. However, it is exceptional in case of double jersey and fleece fabrics, compactness of their structure is the reason for that.

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