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Evoluating the Effect of Spinning Systems on Thermal Comfort Properties of Modal Fabrics

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Abstract: In recent years the importance of clothing comfort became one of the most important feature of the fabrics. The aim of this study is to characterize thermal comfort properties of single jersey fabrics were knitted using 100% modal yarns which were spun in various types of yarn spinning methods such as ring spinning, compact spinning, rotor spinning and airjet spinning. Thermal comfort properties like air permeability, thermal resistance, thermal absorptivity and water vapour permeability of fabrics were tested. The results indicate that compact spinning technology will be appropriate for the summer climate casual wear.

Keywords: knitted fabric, thermal comfort, modal, spinning methods

1. Introduction

Nowadays, there has been growing interest in knitted fabrics due to its simple production technique, low cost, high levels of clothing comfort and wide product range. Consumers today, not only desire aesthetic appeal of apparel, but also its comfort and performance attributes and knitted fabrics can possess stretch, provide freedom of movement, have good handle and achieve higher permeability properties. That’s why knitted structures are commonly preferred for sportswear, casual wear or underwear.

Thermal comfort, the subject of this study, plays an important role on the comfort of wearer. It is related to fabric’s ability to maintain skin temperature and allow transfer of perspiration. It is depended upon the fibre properties, yarn structures, fabric geometry and finishing treatments. Of the various yarn properties yarn bulk, packing coefficient and especially yarn hairiness are important factors. There are many researches focused on comfort properties [1-7], whereas studies on spinning methods including both conventional and modern technologies are rare [8-12].

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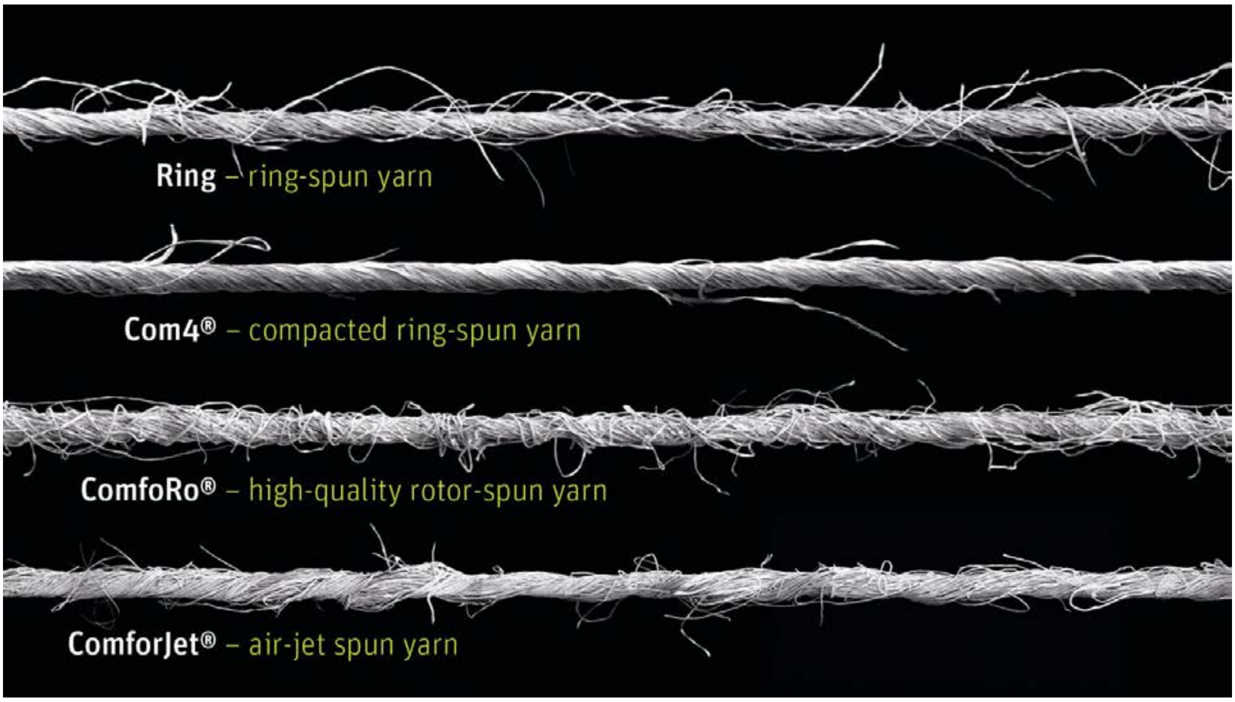

Fig 1. Comparison of Spun Yarns Structure [14]

This research is focused on the effect of the yarn spinning methods on thermal comfort properties of single jersey fabrics. Samples were produced by using modal fibres which are commonly used in knitting industry because of well moisture absorption, high shrinkage resistance besides softness, shiny nature and silky feeling properties.

2. Materials and Methods

Single jersey fabrics were knitted using ring, rotor, compact and airjet yarns from 100 % Modal fibers (Table 1). Whole yarns were spun in the same yarn count (30 Ne). Characteristics of yarns are given in Table 2. The knitting process of the single jersey fabrics was performed on the 28 gauge and 32”diameter circular knitting machine. The knitting process was completed with constant machine settings and the samples were kept under the standard atmospheric conditions for 24 hours for the relaxation.

Comfort properties (thermal conductivity, thermal resistance, thermal absorptivity, relative water vapor permeability, air permeability) were measured besides the weight and thickness of the fabrics.

Alambeta instrument was used to measure thermal conductivity, fabric thickness, thermal resistance and thermal absorptivity values; relative water vapor permeability was measured on Permetest instrument according to ISO 11092. Air permeability measurements were done according to TS 391 EN ISO 9237 using tester FX3300 (Table 3). All measurements were repeated five times and the results were evaluated statistically.

Table 1.Characteristics of Modal Fibres

	Made in	Trading Name	Fibre Length(mm)	Fibre Fineness	Type
Modal Fibres	Austria	Lenzing Modal	38-39 mm	1.30 dtex (3,3 micron)	Bright

Table 2. Characteristics of Yarns

	Yarn Count (Ne)	Twist Coeff. (αe)	Um	CVm	Thin 50%	Thick +50%	Neps +200%	H
Ring	30	3.7	9,31	11,78	0.0	9,20	20,80	6,31
Rotor	30	3.7	11,53	14,57	19.0	35,80	198,30	4,84
Compact	30	3.7	9,52	12,03	0.0	7,50	13,30	4,88
Airjet	30	3.7	9,4	11,86	1.5	8,30	8,30	4,39

3. Results and Discussion

The physical and thermal comfort values of the fabrics are given in Table 3.

Table 3. Fabric properties

Properties		*Ring*	*Rotor*	*Compact*	*Airjet*
Stitch density	*Course/cm*	20	19	20	20
	Wale/cm	14	13	14	14
Thickness (mm)		0,46	0,36	0,42	0,48
Weight (g/m2)		130	138	127	133
Air permeability (lt/m2s)		1924	1710	2020	1650
Thermal conductivity (W/mK)		0,04603	0,04559	0,04468	0,0451
Thermal resistance (m2 K/W)		0,01004	0,00795	0,00951	0,01055
Thermal absorptivity (Ws1/2/m2K)		165,97	185,73	156,03	153,8
Relative water vapor permeability		58,43	63,05	63,96	66,81

As it is known, the yarn structure is dependent primarily upon the raw material, spinning process, spinning unit, machine settings, twist, etc. Length and frequency of fiber ends that are not integrated in the yarn and therefore protrude from the yarn bundle causes hairiness. The fabric structure can be open or closed; voluminous or compact; smooth or rough or hairy; soft or hard; round or flat; thin or thick, etc. [14]. Lower thickness values observed to fabrics made from compact spun yarns and rotor Spun yarns. This may explained by its relation with hairiness. Ring-spun yarns display significantly the highest hairiness. Ring spinning technique caused an increase in hairiness values. In addition, modal fibers cannot be spun effectively in the compact spinning.

3.1. Air Permeability

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 [17]. The results indicate that the air permeability values increase while the weight values of the fabrics decrease.

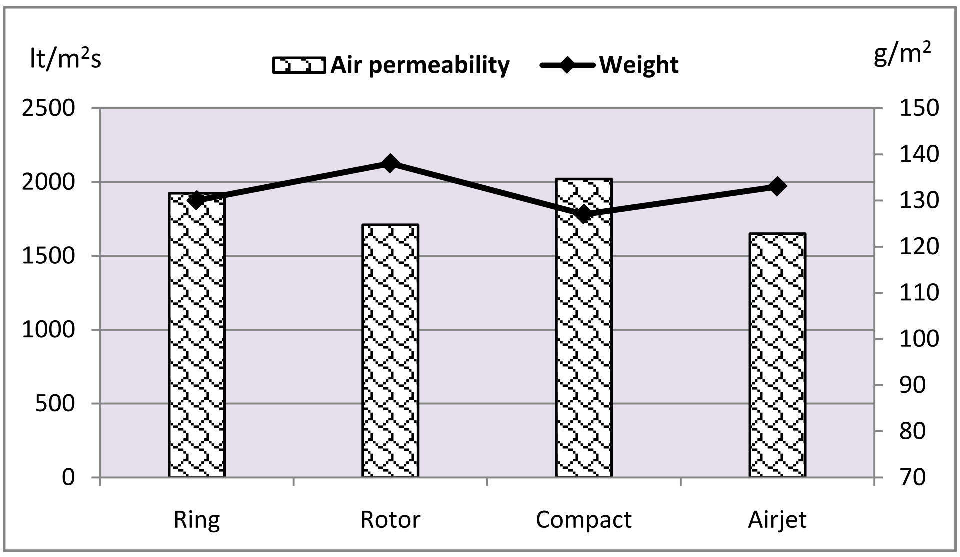

Fig 2. Air permeability values

Construction factors and finishing techniques can have an effect upon air permeability by causing a change in the length of airflow paths through a fabric. Fabrics with different surface textures on either side can have a different air permeability depending upon the direction of air flow [17].

The results are shown in Figure 2 the highest value were obtained for the fabrics made from Compact spun.

3.2. Thermal Resistance and Thermal Absorptivity

Thermal resistance is an indication of how well a material insulates and thermal absorptivity determines the contact temperature of two materials.

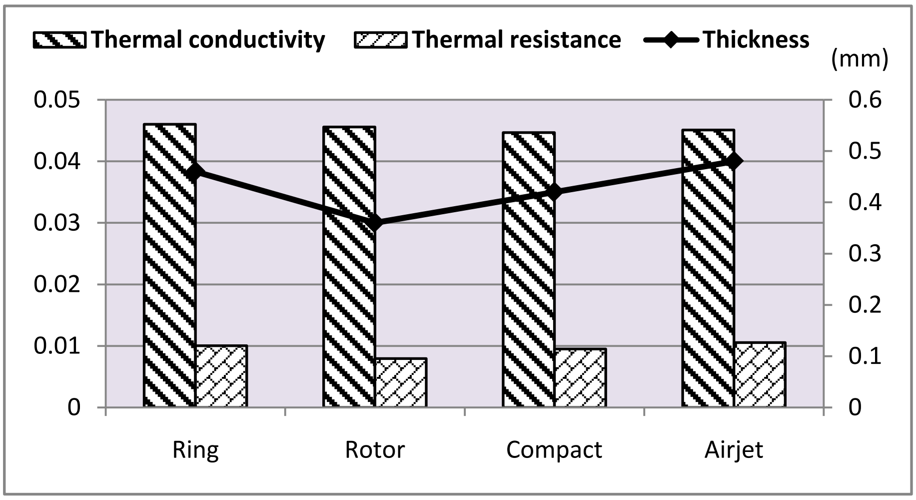

Fig 3. Thermal conductivity, thermal resistance and thickness

According to Figure 3, there was not significant difference in thermal conductivity with diffirent yarn spinning methods. Fabrics made of compact spun had lower conductivity than other samples. As it is known from the literature that thermal conductivity is an intensive property of a material that indicates its ability to conduct heat. Different knitting structures have different comfort properties [5]. It can be seen that important thermal conductivity changes depending on structures of the fabric and chosen material.

Thermal resistance is a measure of the body's ability to prevent heat from flowing through it. Under a certain condition of climate, if the thermal resistance of clothing is small, the heat energy will gradually reduce with a sense of coolness [5].

The results are shown in Figure 3; when the thickness of insulation is increased, the thermal resistance also increases. Fabric sample made from Compact spun and Rotor spun samples had the lowest thermal resistance values, and the highest values were obtained for the fabrics made from Ring spun and Airjet spun.

3.3. Thermal Absorptivity

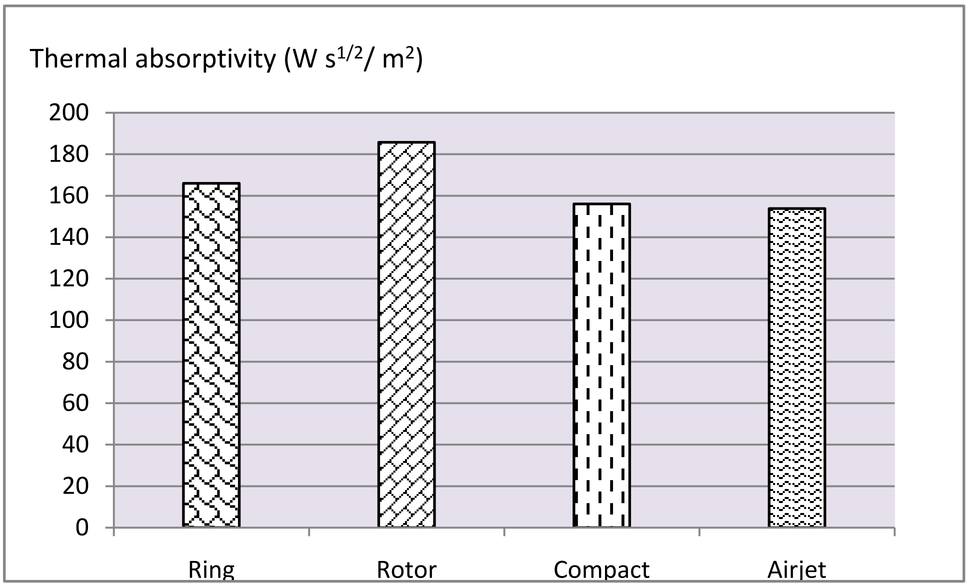

Fig 4. Thermal absorptivity values of samples

Thermal absorptivity is the objective measurement of the warm-cool feeling of fabrics [5-13]. A warm-cool feeling is the first sensation. When a human touches a garment that has a different temperature than the skin, heat exchange occurs between the hand and the fabric. If the thermal absorptivity of clothing is high, it gives a cooler feeling at first contact [5- 15].

In both fabrics made from ring spun and rotor spun with the highest thermal absorptivity values, has the coolest feeling at the beginning of skin contact (Figure 4). This situation is explained by the spinning processes; fiber conditions in rotor spun and ring spun yarn structures.

3.4. Relative water vapour permeability

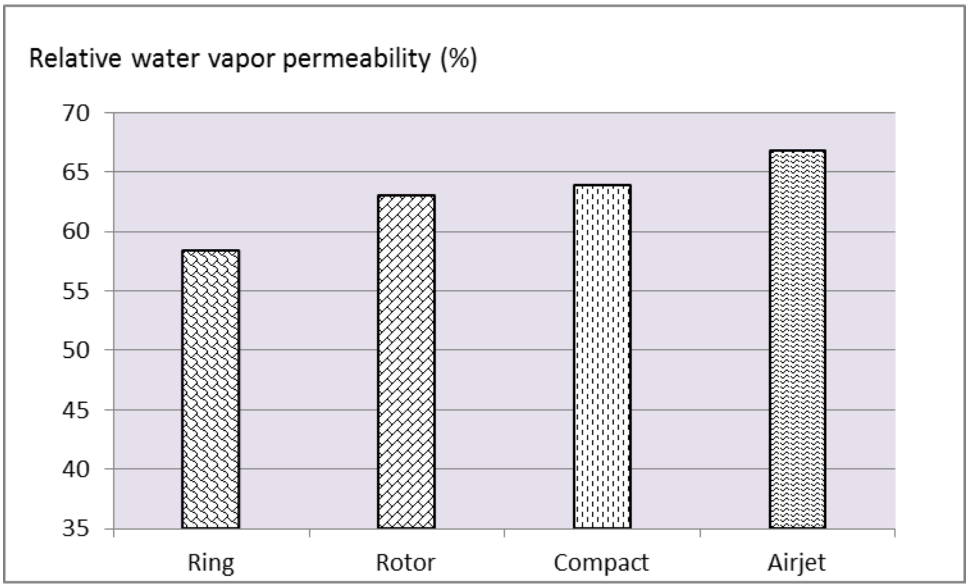

Fig 5. Water vapour permeability results

Relative water vapour permeability is the ability to transmit vapour from the body. If the moisture resistance is too high to transmit heat, by the transport of mass and at the same time the thermal resistance of the textile layers considered by us is high, the stored heat in the body cannot be dissipated and causes an uncomfortable sensation [5-16].

The results are shown in Figure 5 that relative water vapour permeability had significant difference depending on spinning processes. Difference is most probably a consequence of the Compact yarn structure has caused the formation of thinner fabric structure. The transportation of water vapour through a thin fabric will be easier.

4. Conclusion

Yarn structure has a greater or lesser influence on thermal comfort:

To manage a high level of clothing comfort in sportswear or casual wear; thermal conductivity, water vapor permeability and air permeability characteristics are important. Based on the climatic conditions, the requirements from the garments will be changed. The results were evaluated in accordance with these requirements:

- a higher air permeability could be achieved by compact spinning technology,
- a higher water vapour permeability was provided by both compact and airjet spinning technology,

- a higher thermal absorptivity was observed by rotor spinning technology,
- a higher thermal resistance was measured by both ring and airjet spinning technology,
- a lower thermal resistance was measured by compact spinning technology,
- a lower weight values observed by compact spinning technology.

Ultimately, the results indicated that compact spinning technology will be appropriate for the summer climate casual wear with higher air permeability, higher relative water vapour permeability, sufficient thermal resistance, sufficient thermal conductivity, and also lower weight and thickness values.

Note: This paper was presented in 17th World Textile Conference AUTEX2017.

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