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Research Article

# Analysis on thermal comfortability of different three thread fleece fabric

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***Abstract***

*This research work was carried out to study the thermal comfort characteristics of three thread fleece fabrics. Polyester filament, spun polyester, polyester/cotton and 100% cotton yarn was used to produce different fifteen samples with different fiber composition having same GSM (280) and thermal characteristics such as thermal conductivity, thermal resistance, relative water vapor permeability and their impact were analyzed. 90% cotton/10% polyester was observed with lowest thermal conductivity and with increasing the polyester percentage thermal conductivity increasing up to 65% cotton/ 35% Polyester. In case of thermal resistance higher resistance was observed for 90% cotton/10% polyester and with the increasing of polyester percentage thermal resistance decreases. The sample containing 90% cotton/10% polyester to 80% cotton/20% polyester showed the lowest and 65% cotton/35% polyester was found highest water vapor permeability. After total analysis of the samples 90% cotton/10% polyester containing three thread fleece fabric are recommended as best winter item.*

***Keywords:*** *Thermal Conductivity, Thermal resistance, Water vapor permeability, Three thread fleece fabric.*

## 1. Introduction

Comfort is one of the most important properties of textiles for consumers in terms of casual wear product. Due to its easy manufacturing technique, low production cost and several privileges they provide for consumers, such as high elasticity, freedom of movement, good handle, ease of care, etc (N. Oglakcioglu, *et al*, 2007). Flat knitted fabrics are much more appreciated to produce casual wear products. The usage of yarns made of acrylic fiber and its blends are also very common in the market, especially for winter wear because of their wool-like touch, easy care and low density (P Mal, *et al*, 2016). Clothing comfort is related to the thermoregulation and moisture transport characteristics of the fabrics which explain the transfer of heat and mass between the clothed body and the environment. Thermoregulation characteristics are measured basically with thermal resistance, thermal conductivity and thermal absorptivity. Thermal resistance is directly proportional to thickness and inversely proportional to thermal conductivity and it is relevant to thermal insulation (MB Sampath, *et al*, 2011).

As a new concept, thermal absorptivity is about the feeling of warm or cold. Although it is not common to sweat because of weather conditions in winter time, air permeability and water vapor permeability of the fabrics also have an impact on the thermoregulation characteristics of the fabrics and it is concerned as breathability (A Gericke, *et al*. 2010). It is the ability of clothing to allow the transmission of moisture vapor by diffusion and to facilitate evaporative cooling (R Bagherzadeh, *et al*. 2011).

Water vapor permeability depends on air permeability (MM Adler *et al*. 1984). On the other hand, Relative water vapor permeability indicates the transportation of moisture through the fabric from the perspective of thermo-physiological comfort since water is a good conductor of heat and amount of moisture that is present in the fabric influences the thermal resistance. Thermal comfort properties of textile materials have gained the attention of researchers in recent times. The acceptability of a textile fabric largely depends on the comfort aspects which involve thermal properties air permeability and water vapor permeability (J Huang, 2006),(D.A. Watkins *et al*. 1981).

Although a plethora of researches have been conducted on the mechanical properties of textile fabrics. They have hardly played any role during the actual use of the fabrics. In contrast, comfort properties determine the way in which the heat, air and water vapor are transmitted across the fabric. During heavy activities, the body produces lots of heat energy and the body temperature rises. To reduce the temperature, the body perspires in liquid and vapor form. When this perspiration is evaporated to

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atmosphere, the body temperature reduces. So the garments should allow the perspiration to pass through to ensure comfort. Therefore, thermal and water vapor transmission properties of fabrics are very important for the body comfort. Besides the 'warm-cool' feeling upon the first brief contact of the fabric with the human skin is also a very important parameter that influences the comfort properties of textile fabrics (M.J. Pac *et al*. 2001).Thermal comfort properties of textile fabrics are actually influenced by the gamut of fiber, yarn and fabric properties. The type of fiber, spinning technology, yarn count, yarn twist, yarn hairiness, fabric thickness, fabric cover factor, fabric porosity and finish are some of the factors, which play decisive role in determining the comfort properties of fabrics (Y. Li, 2001). Researchers (X. Wan *et al*. 2009) showed that there is an optimum fiber diameter, closely matched by penguin feathers, at which the fibrous materials are at their best in blocking thermal radiation. Some researchers have also studied the effect of micro denier fiber on the comfort aspects of fabrics and reported that micro-denier fibers give lower thermal conductivity and higher thermal resistance (L. Schacher, *et al*. 2000), (G. Ramakrishnan, *et al*. 2009). The thermal comfort properties of cotton-angora rabbit fiber blended rib knitted fabrics and found that the mixing of Angora fiber beyond 25% affected the thermal comfort properties significantly (N. Oglakcioglu *et al*. 2009). A Study (N. Du *et al*. 2007) demonstrated that the optimum porosity of uniform fibrous porous materials for the thermal insulation is very much dependent on the fiber emissivity and fiber radius.

A group of authors (N. Ozdil, *et al*. 2004) experimentally verified that yarn properties like yarn count, yarn twist and combing process influence different thermal comfort properties of 1x1 rib knitted fabrics. The effect of novel yarn structures has also been investigated by some researchers (A. Das, *et al*. 2004), A. Das, *et al*. 2007). The fabrics produced from bulked and hollow yarn structures give the higher thermal resistance as it can entrap the air within the intra yarn pores. Fleece fabrics are generally used to prevent cold in winter. They are often used as sweater, hoody.

So the thermal conductivity property is a great issue to be acknowledged. Again the thermal transmittance of the fleece fabric is also an important parameter. Fleece fabrics vary from one another depending mainly on the composition of yarn, stitch length and GSM of fabric (S. Gunesoglu, *et al*. 2006).

## 2. Material and Method

Jiunn Long circular knitting machine having 32 inch diameter, 20 gauge and 96 feeders were chosen for sample production. Total fifteen sample were produced with below fibre composition and having 280 GSM.

**Table 1** List of fibre composition of samples

| Sample No | Composition (Cotton/Polyester) | Sample No | Composition (Cotton/Polyester) | Sample No | Composition (Cotton/Polyester) |
|---|---|---|---|---|---|
| **1** | 90/10 | **6** | 75/25 | **11** | 60/40 |
| **2** | 85/15 | **7** | 70/30 | **12** | 60/40 |
| **3** | 85/15 | **8** | 65/35 | **13** | 60/40 |
| **4** | 85/15 | **9** | 65/35 | **14** | 55/45 |
| **5** | 80/20 | **10** | 65/35 | **15** | 55/45 |

After getting the samples thickness was measured by digital fabric thickness tester and thermal conductivity and thermal resistance were completed by Lee's disc method. Average value of every three samples for each composition was performed and tabulated. Below equation was used to calculate the thermal conductivity and thermal resistance.

Amount of Heat Transfer (Joules/sec-square meter-°C)

$$H=\frac{P}{AaTa+As\left(\frac{Ta+Tb}{2}\right)+AaTa+AcTc}$$

and

Thermal Conductivity (k)

$$=\frac{H\times Thickness\times\{As\left(\frac{Ta+Tb}{2}\right)\}+2AaTa\}}{2\pi r^2\times(Tb-Ta)}\ W/m\text{-}K$$

Where,

Output temperature= $T_a$°C, Input Temperature with material=$T_b$°C, Input Temperature without material= $T_c$°C, $A_a$, $A_b$, $A_c$ = Disc surface area, P= Power, $A_s$ = Sample surface area.

Refond water vapor permeability tester was used to calculate water vapor permeability. Keeping two as RPM and with eight cups used. Below formula was used to calculate water vapor permeability:

Vapor Permeability (N) = (Before Weight - After Weight) gm = ($W_1$-$W_2$) gm

Water Vapor Permeability $=\frac{24\times N}{A\times t}$, Where, A= area of the cup = 1.043 $m^2$, t= 1 hour

After completing the test data use tabulated.

**Table 2** Thermal comfortability properties of different compositions

| Sample No | Composition (Cotton/Polyester) | Thickness (m) | Thermal Conductivity (W/m-K) | Thermal Resistance ($m^2$-K/W) | Water Vapor Permeability (gm/$m^2$) |
|---|---|---|---|---|---|
| **1** | 90/10 | 0.0012296 | 0.0019004 | 0.7876552 | 7.8825795 |
| **2** | 85/15 | 0.0014200 | 0.0028699 | 0.4947916 | 7.7775647 |
| **3** | 85/15 | 0.0012400 | 0.0028914 | 0.4288581 | 8.1749760 |
| **4** | 85/15 | 0.0011700 | 0.0028208 | 0.4147815 | 6.8341323 |
| **5** | 80/20 | 0.0014609 | 0.0032168 | 0.5528652 | 5.6025678 |
| **6** | 75/25 | 0.0012552 | 0.0027680 | 0.4378256 | 8.3091877 |
| **7** | 70/30 | 0.0012425 | 0.0028407 | 0.3827211 | 7.5906040 |
| **8** | 65/35 | 0.0014000 | 0.0032976 | 0.5168399 | 11.9614823 |
| **9** | 65/35 | 0.0012320 | 0.0028998 | 0.4758357 | 12.0354362 |
| **10** | 65/35 | 0.0012413 | 0.0025613 | 0.4523388 | 8.8053691 |
| **11** | 60/40 | 0.0011667 | 0.0025138 | 0.4331600 | 8.0966443 |
| **12** | 60/40 | 0.0011013 | 0.0025367 | 0.4052217 | 8.1395973 |
| **13** | 60/40 | 0.0012507 | 0.0027597 | 0.4229795 | 8.9127517 |
| **14** | 55/45 | 0.0012544 | 0.0026379 | 0.5325933 | 10.5406711 |
| **15** | 55/45 | 0.0012320 | 0.0029673 | 0.4650185 | 10.1540940 |

## 3. Results and Discussion

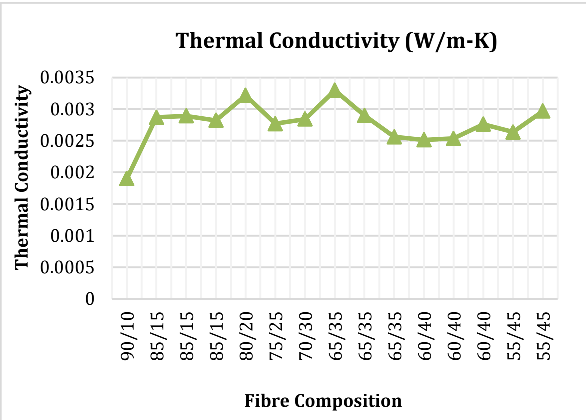


**Fig 1** Thermal conductivity of different fibre composition

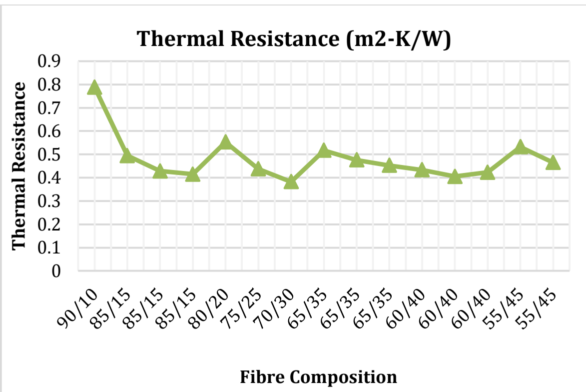


**Fig 2** Thermal resistance of different fibre composition

After thermal conductivity test fig 1 was generated and observed that 90% Cotton/10% Polyester fabric has the lowest thermal conductivity which reflects on fig 2 that the same composed fabric has the highest thermal resistance. 80% cotton/20% polyester and 65% cotton/35% polyester shows higher thermal conductivity value though their thickness were in the higher range.

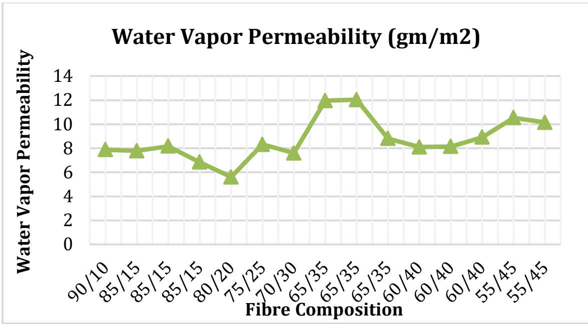


**Fig 3** Water Vapor Permeability of different fibre composition

From fig 3 it is clear that lowest water vapor permeability was found for 80% cotton/20% polyester fabric. 65% cotton/35% polyester has the highest water vapor permeability. Samples ranged from 90% cotton/10% polyester to 80% cotton/20% polyester has the lower water vapor permeability.

## Conclusions

It is confirmed that presence of polyester in three thread fleece fabric can affect the thermal comfortability. A range of 25% to 35% presence of polyester with cotton raises the thermal conductivity and water vapor permeability which increases the coolness where as 10% to 20% of polyester with cotton gives better warmness for lower thermal conductivity and air permeability.

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