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# Investigating comfort properties of 3/1 Z twill weaved denim fabrics

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**Abstract.** Denim jeans are preferred because of durability and easy washing properties. Nowadays the expectations of consumers from denim fabrics are changed towards design and comfort properties. For this reason, thermal and moisture comfort properties of denim fabrics should be examined. This paper aims to investigate thermal, air permeability and moisture management properties of 3/1 Z twill weaved denim fabrics. These fabrics are produced mainly from cotton with different yarn count and cover factors are close to each other.

**Key Words:** denim fabrics, thermal comfort, moisture management.

## 1. Introduction

Denim is a sturdy cotton warp-faced textile in which the weft passes under two or more warp threads. This twill weaving produces a diagonal ribbing that distinguishes it from cotton duck. The most common denim is indigo denim, in which the warp thread is dyed, while the weft thread is left white. As a result of the warp-faced twill weaving, one side of the textile is dominated by the blue warp threads and the other side is dominated by the white weft threads. This causes blue jeans to be white on the inside[1].

Denim garment is one of the most important and highly used textile clothing, regarding its exclusive features including color, versatile appearance and high strength that are widely used by young people. To create diversity in denim garment it is necessary to apply special techniques and new substances to respond the huge market demand[2]. For this reason thermal and moisture management properties of denim fabrics have been examined. Thermal comfort features of fabrics like thermal resistance, thermal absorptivity and thermal conductivity affects clothing comfort. Comfort is a pleasant state of physiological, psychological, neurophysiological and physical harmony between a human being and environment[3].

Moisture management properties of fabrics relevant with removal of sweat in liquid form from body surface. It is important for especially performance and technical fabrics, ensuring the comfort and protection that consumers demand.

## 2. Material and Method

Eight different 3/1 Z twill weaved denim fabrics is used in the experiments. Fabrics are made mainly from cotton yarn. The properties of fabrics measured by standard methods are presented in Table 1.

All the measurements were conducted after conditioning of the fabrics for 24 hours under the standard atmosphere conditions 20°C±2 temperature and 65±2 % relative humidity. The moisture management



instrument (MMT) is used to measure dynamic liquid transport properties of knitted fabrics in three dimensions according to AATCC 195-2009. Alambeta test device is used for measurements of thermal conductivity, thermal resistance, thermal absorptivity and thermal diffusivity properties of fabrics. Also Air permeability measurements are made SDL Atlas Air permeability instrument according to EN ISO 9237 standards with 100 Pa air pressure and 20 mm<sup>2</sup> test area.

**Table 1.** Properties of tested 3/1 Z twill weaved denim fabrics.

Composition	Weft Yarn No. (Ne)	Warp Yarn No. (Ne)	Weave	Weight (g/m <sup>2</sup> )	Thickness (mm)	Weft Sett (thread/cm)	Warp Sett (thread/cm)	Cover Faktor
%100 Cotton	6.8 Cotton	5.7 Cotton	Twill 3/1 (Z)	502	0,92	26	18	27,15
%60 Cotton, %40 CLY	8.1 Cotton/Cly	9.1 Cotton/Cly	Twill 3/1 (Z)	430	0,81	27	21	26,56
%100 Cotton	8.0 Cotton	7.2 Cotton	Twill 3/1 (Z)	378	0,67	27	18,5	26,58
%95 Cotton, %4 PES %1 Elastan	7.5 Cotton	12.0 Cotton/ Polyester+ Elastan	Twill 3/1 (Z)	362	0,82	29	19	26,32
%100 Cotton	8.9 Cotton	12.2 Cotton	Twill 3/1 (Z)	343	0,74	30	22	26,93
%100 Cotton	6.8 Cotton	7.2 Cotton	Twill 3/1 (Z)	450	0,83	28	19	26,68
%98 Cotton %2 Elastan	9.0 Cotton	10.0 Corespun	Twill 3/1 (Z)	367	0,69	30	22	27,04
%100 Cotton	14.0 Cotton	18.1 Cotton	Twill 3/1 (Z)	251	0,5	33	27	25,63

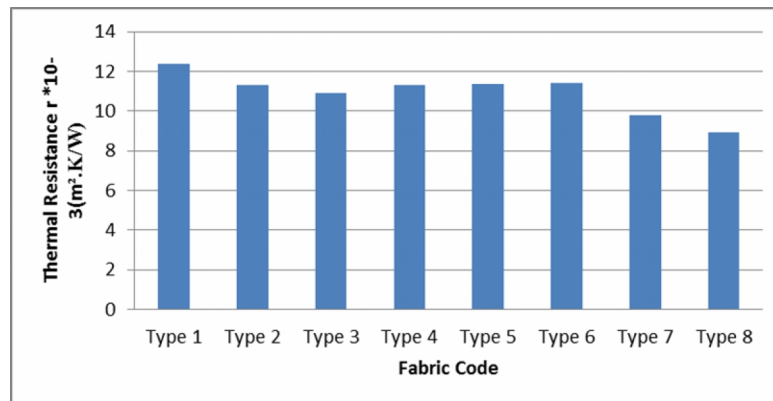
Cover factor measurement of fabrics are made according to pierce's cover factor formulations .K<sub>1</sub> warp cover factor , K<sub>2</sub> weft cover factor and Fc total fabric cover factor value[4].

$$F_c = K_1 + K_2 - (K_1 \times K_2) / 28 \quad (1)$$

### 3. Results and Discussions

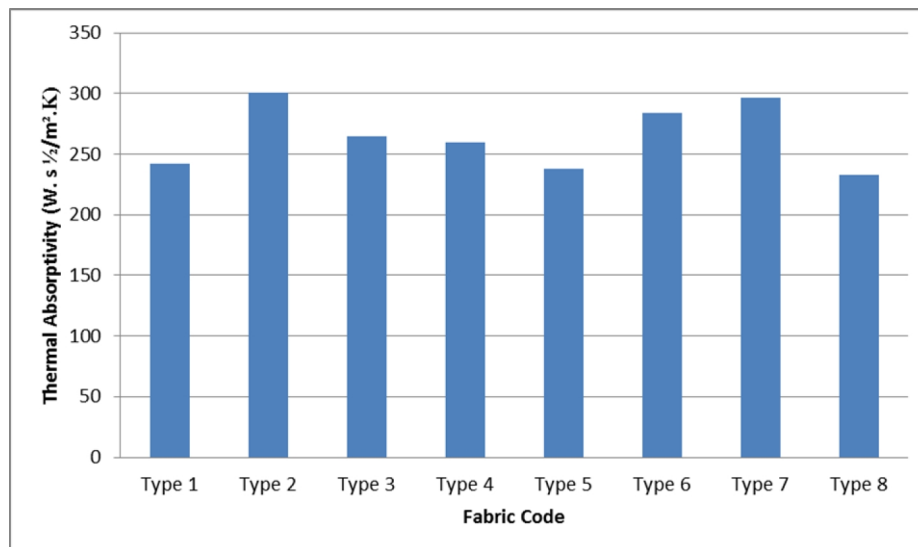
#### 3.1 Thermal Properties of Fabrics

Thermal resistance values of fabrics are shown in Figure 1. The highest thermal resistance value was seen in Type 1, the highest cover factor and weight fabric. The lowest thermal resistance value was seen Type 8, the lowest cover factor value and weight fabric. So we can say for same yarn weaved fabrics, If cover factor of fabric increase, thermal resistance will increase. When we compare Type 4 and Type 7 elastan weft yarn used fabrics, thermal resistance of Type 4 is higher than Type 7. This is most probably due to polyester yarn composition in the weft yarn and thickness difference.



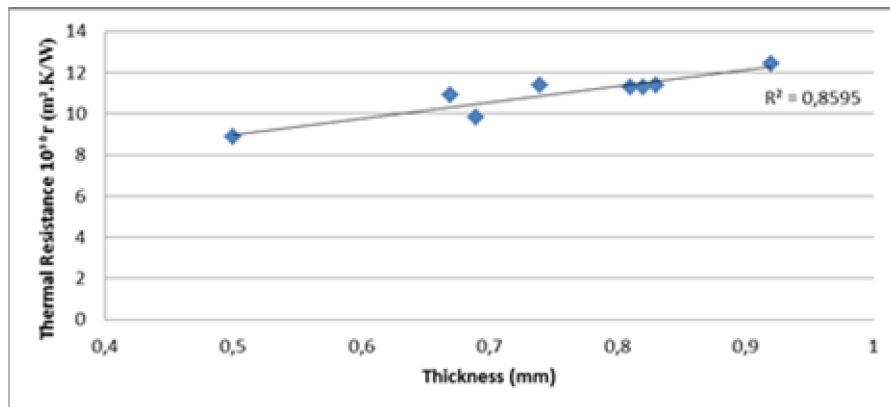
**Figure 1.** Thermal resistance values of fabrics.

The thermal absorptivity values of fabrics are shown in Figure 2. The highest thermal absorptivity value were seen Type 2, %60 cotton, %40 cly fabric. This is most probably due to content of cly fabric. The lowest thermal absorptivity value were seen Type 8, which is the lowest thermal resistance value fabric.



**Figure 2.** Thermal absorptivity values of fabrics.

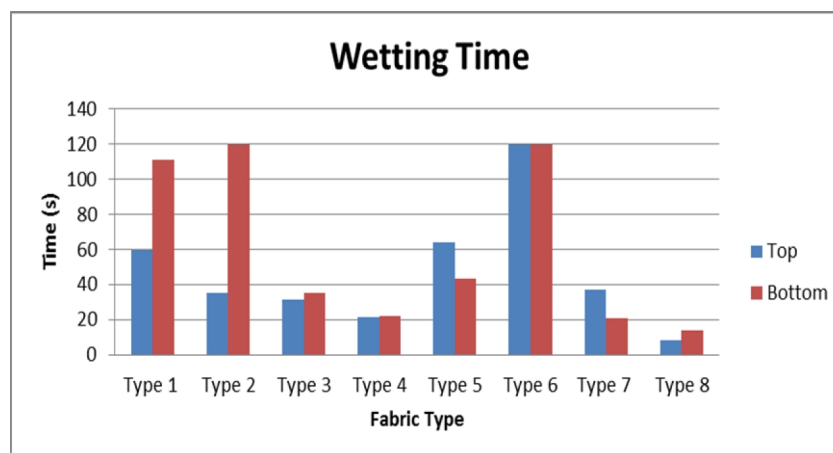
Generally, there was a strong relationship between the thickness and the thermal resistance of the fabric. The most important factor affecting the thermal resistance was the thickness of the fabric. The relationship thermal resistance and thickness values of measured fabrics were given in Figure 3. The correlation coefficient is 0,8595. So we can say there is strong relationship between thermal resistance and thickness of measured fabrics.



**Figure 3.** The relationship between thermal resistance and thickness

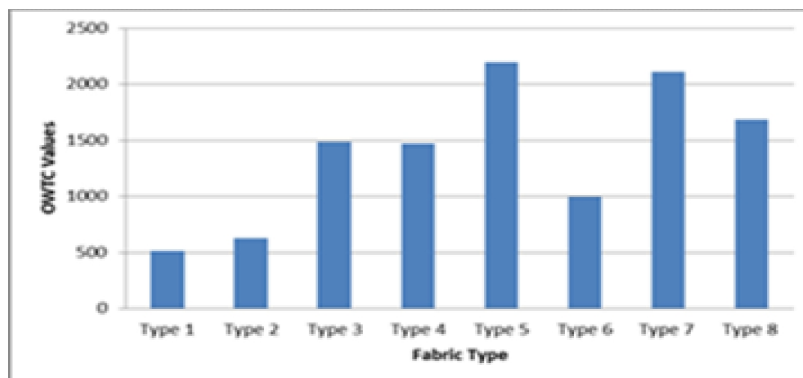
### 3.2 Moisture Management Properties of Fabrics

Wetting time are the time period in which the top and bottom surfaces of the fabric just start to get wetted respectively. The wetting time values of tested fabrics are given in Figure 4. Type 6 fabric showed highest wetting time values. This means sweat solution slowly absorbed by top and bottom surfaces of fabric. On the other hand, Type 8 fabric showed lowest wetting time values in top and bottom surfaces, indicating that sweat solution more rapidly absorbed than the other fabrics. This is most probably due to yarn count of this fabric, with finer yarn, the thickness of the fabric decreases. Although the thin fabrics were treated with equal amounts of water, the wetting time was lower [5,6].



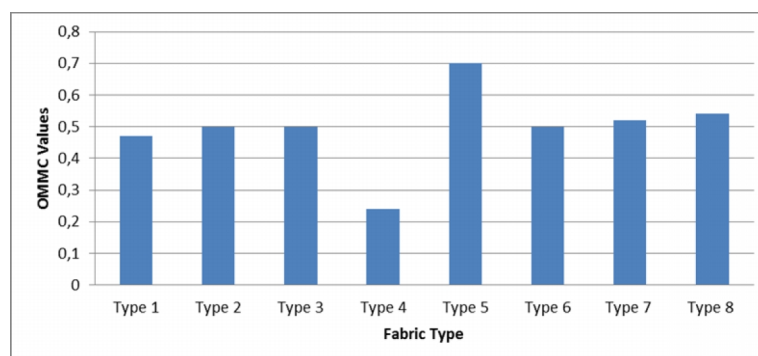
**Figure 4.** Wetting time values of fabrics.

Accumulative one-way transport index (OWTC) is the difference of the accumulative moisture content between the two surfaces of the fabric. OWTC values of tested fabrics are given in Figure 5. As can be seen from the figure, Type 5 fabric showed highest OWTC value. Also the OMMC value of this fabric is highest. This means sweat can be thrown away one side of fabric to other side easily than other tested fabrics. The lowest OWTC value were seen Type 1, the highest cover factor value and thicker yarn count number fabric.



**Figure 5.** OWTC values of fabrics.

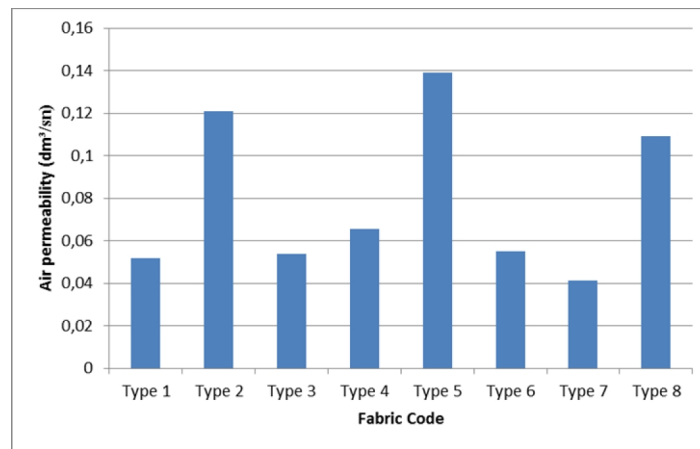
Overall Moisture Management Capacity (OMMC) is an index to indicate the overall capability of the fabric to manage the transport of liquid moisture. Overall moisture management properties of tested fabrics are given in Figure 6. Type 4, cotton polyester and elasthan weft yarn weaved fabric showed poor OMMC value according to MMT scale. On the other hand, OMMC value of Type 7, %98 cotton and %2 elasthan weaved fabric were good. This is most probably due to elasthan yarn composition and yarn count. The highest OMMC value was seen in Type 5, %100 Cotton weaved fabric. Additionally, this fabric has very good OWTC value according to MMT grading scale.



**Figure 6.** OMMC values of fabrics.

### 3.3 Air Permeability Values of Fabrics

Air permeability values of fabrics are shown in Figure 7. The highest air permeability value were seen in Type 5, %100 Cotton twill weaved fabric. Type 2, Cotton/Cly weaved fabric were showed second highest air permeability value. The lowest air permeability value were seen in Type 7, corespun warp yarn weaved fabric. Air permeability values of Type 1, Type 3 and Type 6, %100 cotton yarn weaved fabrics are close to each other. Because these fabrics has similar warp and weft setting value.



**Figure 7.** Air permeability values of fabrics.

#### 4. Conclusion

Consequently, the highest cover factor and thickness value fabric showed highest thermal resistance and lowest cover factor and thickness value fabric showed the lowest thermal resistance value. This supports previous studies that the thermal resistance of the fabrics depends on the thickness of fabrics [7]. Type 8 fabric showed lowest wetting time values in top and bottom surfaces, indicating that sweat solution more rapidly absorbed than the other fabrics. This is most probably due to yarn count of this fabric, with finer yarn, the thickness of the fabric decreases. Although the thin fabrics were treated with equal amounts of water, the wetting time was lower. A larger OMMC indicates a higher overall moisture management capability of the fabric [8]. The highest OMMC value was seen Type 5, %100 Cotton weaved fabric and the lowest OMMC value was seen Cotton/Polyester with elastan weft yarn weaved fabric. On the other hand, OMMC value of Type 7, %98 cotton and %2 elastan weaved fabric were good. This is most probably due to elastan yarn composition and yarn count.

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