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IMPACT OF REPEATED WASHINGS ON THE THERMAL INSULATION PROPERTIES OF WOVEN COTTON FABRIC

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Abstract: *Clothing is required for protection of body from environmental effect as well as comfort. Mostly all clothing undergoes many washings cycles during its useful life. It can alter the fabric dimensions, weight and cover factor which may ultimately affects the heat transport properties with other important properties. In this paper the impact of repeated washings on the thermal insulation properties of woven cotton fabric was studies. Result reveals that thermal insulation values of washed sample were decreases after repeated washings.*

Keywords: *Cover Factor, Dimensional stability, Fabric thickness Fabric weight, Thermal insulation*

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1. INTRODUCTION

In general, there are two aspects of wear comfort of clothing: first thermo-physiological wear comfort, which concerns the heat and moisture transport properties and second, skin sensational wear comfort which concerns the mechanical contact of the fabric with the skin. The clothing comfort is dependent upon the low stress mechanical, thermal and moisture transfer properties of the fabrics. The heat transport and movement of moisture through a clothing is probably the most important factor in clothing comfort [1-4].

A number of washing cycles are required for all clothing during its useful life. During washings, the clothing is subjected to thermal, mechanical and physical actions. It may change the fabric dimension and fabric physical parameters such as cover factor, fabric thickness and fabric weight; which may alter the heat transport properties with some other properties. Therefore, the study the effect of repeated washings on heat transport property has fundamental importance. In this paper the effect of repeated washings has been studied on the thermal insulation properties of woven cotton fabric.

2. MATERIAL & METHOD

2.1 Sample plan

For this study, the fabric was prepared using 100% cotton yarn [Table 1] for the study. Five test fabric samples were prepared by subjecting this fabric for 0, 4, 8, 12 and 16 washing cycles.

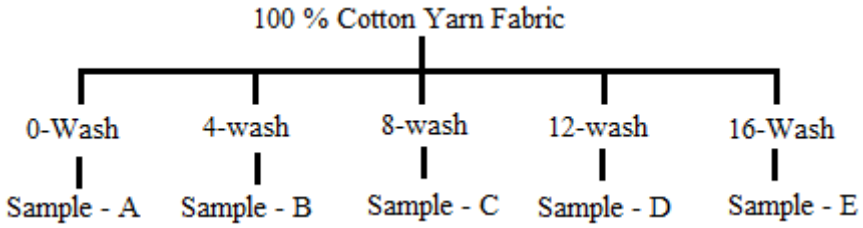

Figure 1 Sampling plan

2.2 Raw Material

Ring spun is made using J-34 type of cotton fibres. The parameter of yarn has given in Table 1.

Table 1 Yarn parameter

Type of fibre	Cotton variety	Count of warp yarn	Count of weft yarn	Twist per inch (in single yarn)	
Cotton	J-34	$2/40^{s}$	20^{s}	26 (in warp)	18(in weft)

The yarn in the hanks form firstly scoured, bleached, anti-chlorine and optical brightened as in practice in small scale industry for production of fabric. This yarn is used for production of woven fabric for sale in domestic market. This is cost effective process. The details recipes used in scouring, bleaching, anti-chlorine and optical brightening treatments are given in the Table 2, Table 3, Table 4 and Table 5 respectively.

Table 2 Scouring recipe

Hydrochloric acid	5cc/lit.
Temperature	27˚±1˚
Time	15 min
Material to liquor	1:20

Table 3 Bleaching recipe

Bleaching powder ($CaOCl_2$)	7gm/lit
By caustic soda drops PH	10.8 - 11
Wetting agent (Turkey red oil)	1gm/lit
Temperature	27˚±1˚
Time	90 min
Material to liquor	1:20

Table 4 Anti-chlorite recipe

Sodium hydro-sulphite	1gm/lit
Temperature	27˚±1˚
Time	15 min
Material to liquor	1:20

Table 5 Optical Brightening recipe

Tinopal	0.5%
Material to liquor	1:20
Temperature	27˚±1˚
Time	5 min

2.3 Fabric Samples Preparation

Plain woven fabric has been made in Cimco Over Pick Power Loom using processed yarn (scoured, bleached, anti-chlorine and optical brightened). The loom width is 44”. In this loom shuttle is used for carrying the weft and it inserts 140 picks per minute. Fabric constructional particular are given in Table 6.

Table 6 Fabric constructional particulars

Fabric Sample	Weave	Linear density (Ne)		Thread Density	
		Warp	Weft	Ends per inch	Picks per inch
100% Cotton Fabric	Plain	2/40s	20s	52	48

2.4 Washing of fabric

The fabrics were washed at 27°C in semi automatic washing machine using 0.75 g/l solution of non-ionic detergent while material to liquor ratio was kept as 1:40. One washing cycle completes in 12 minutes. Fabrics were washed, rinsed in clean water and water is extracted by drier and samples were dried in sun light. For the study, 5 sampled of fabric were prepared by processing the fabric samples at 0 wash, 4 wash, 8 wash, 12 wash & 16 wash (Figure 1). Results have been analyzed statistically.

2.5 Test Method

The fabric samples are tested for various properties. Before test each samples are conditioned as per standard test method.

The ends and picks per inch of woven fabric samples were assessed visually by using a pick glass according to the (IS: 1963-81) standard test method [5]. The weave density was measured from three different areas of each woven fabric samples; the average of three reading was then calculated.

Fabric cover factor was evaluated by Peirce formula expressed as:

$$Fabric\ cover\ factor(K_c) = K_1 + K_2 - \frac{K_1 \times K_2}{28}$$

Where, K_1 = Warp cover factor, K_2 = Weft cover factor [6].

The Kawabata Evaluation System was used for fabric thickness determination [7]. In this case, fabric thickness is measured by measuring compression properties: the effective dimension of the specimen is a compressed circular area of $2cm^2$. The specimen is compressed by two circular plates of steel having an area $2cm^2$. The velocity of the compression is 20 micron/sec. The fabric thickness is taken as the thickness when P (pressure) = 0.5 g-f/cm^2 and the unit is taken in T [mm].

Fabric weight was measured by Kawabata evaluation system [8]. The unit is taken in [mg/cm^2]. The fabric weight was measured from three different areas of each woven fabric samples.

Dimension stability was measured according to the BS 4931 Standard Test Method for preparation, marking and measuring of textile fabrics, garments and fabric assemblies in tests for assessing dimensional change [9].

Thermal Insulation value was measured using KES-FB 7 thermo-labo II, thermal insulation tester [10]. The test method was used Dry Contact Method and air Velocity kept at 30cm/sec. For each fabric samples 3 readings were taken and average calculated.

3. RESULTS AND DISCUSSION

The effect of repeated washing on thermal insulation value of woven fabric was analyzed. And result are tabulated in Table 7.

Table 7 Thermal Insulation (Tog value) in relation to no. of wash cycle and fabric factors

Sample code	No of wash cycle	Fabric Factors				Thermal Insulation (Tog value)
		Fabric Cover Factor	Fabric Thickness at pressure 0.5 g-f/cm² in [mm]	Fabric Weight [mg/cm²]	Fabric Shrinkage [cm²]	
A	0 wash	17.90	0.857	12.168	0.00	1.08
B	4 wash	18.29	0.921	13.74	23.28	1.07
C	8 wash	18.29	0.924	13.80	25.28	1.06
D	12 wash	18.57	0.926	13.88	27.52	1.05
E	16 wash	18.95	0.928	14.05	28.37	1.04

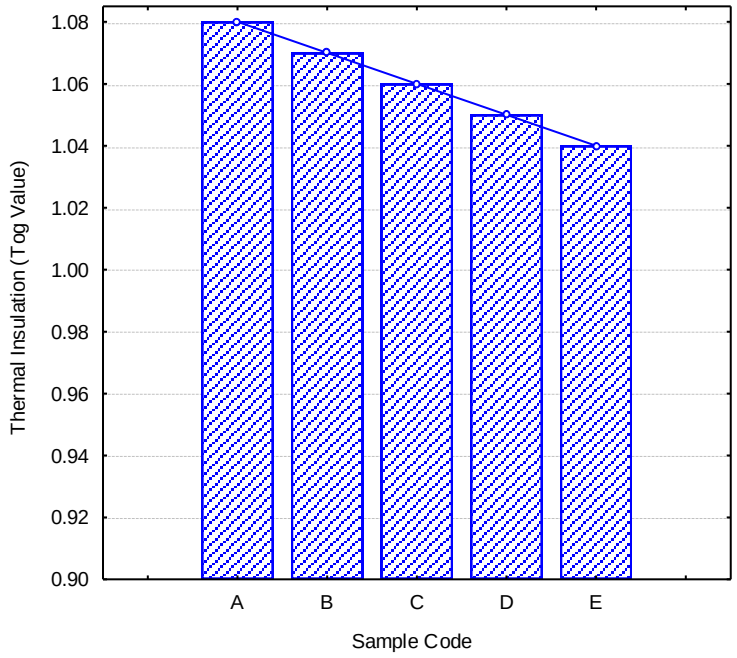

Figure 2 Change in Thermal insulation after repeated washing

Thermal insulation is an important measure for analyzing the effect of material properties on heat transfer. Result of thermal insulation value are tabulated in Table 8 and effect

shown in Figure 2, shows that thermal insulation value of washed samples were decrease after repeated washing cycles (4, 8, 12, 16 wash). This insulation value decreases due to reduction of enclosed air spaces due to fabric shrinkage. Shrinkage reduce the inter yarn porosity. However, the shrinkage also increase fabric thickness, but the effect of reduction in inter yarn porosity is more prominent.

Table 8 Correlation(R) of Thermal insulation with fabric factors

Factors	Correlation(R) of Thermal insulation with fabric factor
Cover Factor	-0.97
Fabric Thickness	-0.76
Fabric Weight	-0.80
Fabric Shrinkage	-0.81

3.1 Effect of fabric cover factor on thermal insulation

A graph has been plotted showing the relationship between thermal insulation and fabric cover factor (Figure 3).

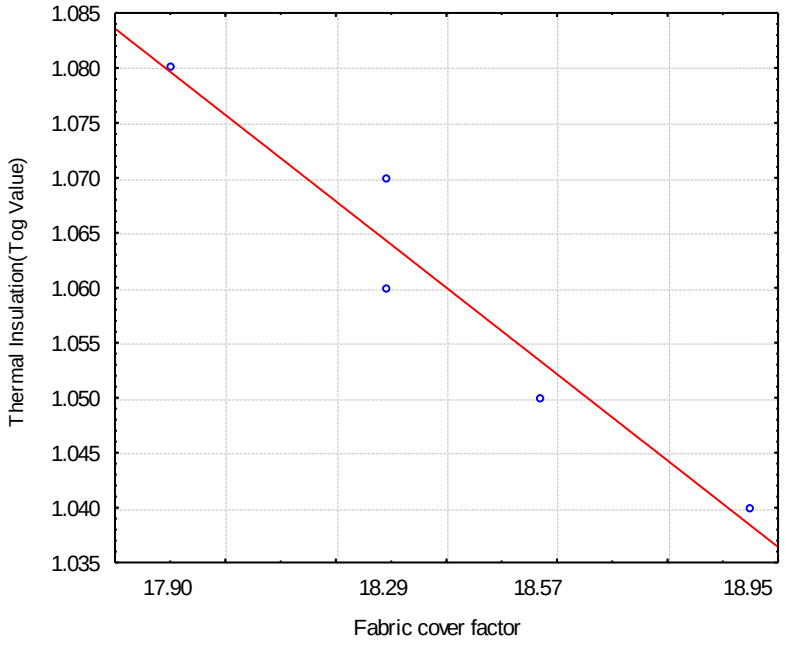

Figure 3 Contour plot of Cover factor Vs Thermal Insulation

It can be observed from Figure 2 that with increase of cover factor, Thermal insulation value decrease which may be due to the arising of the fabric shrinkage.

The thermal insulation of the fabrics has very good correlation (R= -0.97) with fabric cover factor [Table 8].

3.2 Effect of fabric thickness on thermal insulation

A contour plot has been drawn showing the relation of thermal insulation with fabric thickness (Figure 4).

It has been found Figure 3 indicate that with increase of fabric thickness, thermal insulation value found to be decrease slightly. This is due to prominent effect of reduced enclosed still air in the fabric structure due to enhanced cover factor and fabric weight.

The thermal insulation of the fabrics has average correlation (R= -0.76) with fabric thickness [Table 8]. This may be due to the effect of other factor than fabric thickness.

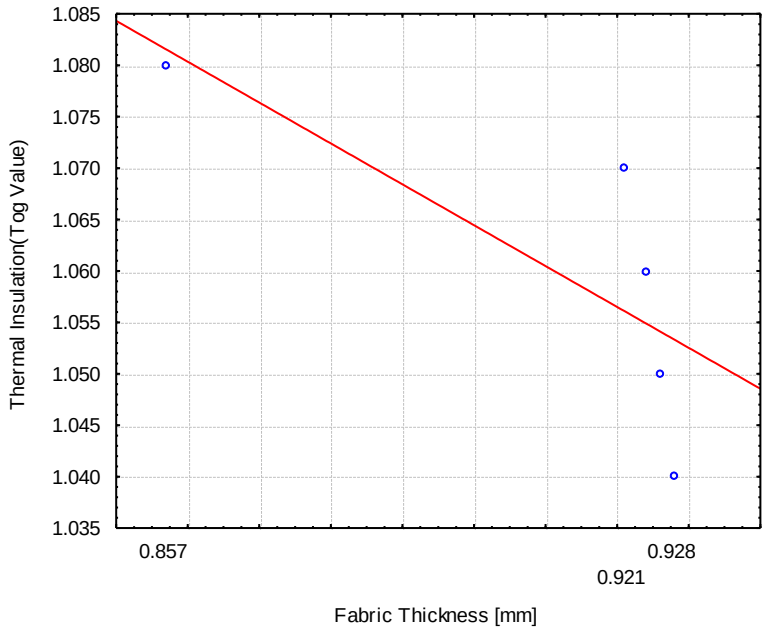

Figure 4 Contour plot of Fabric Thickness Vs Thermal Insulation

3.3 Effect of fabric weight on thermal insulation

The relation between thermal insulation and fabric weight is shown in the Figure 5.

It has been observed from the above Figure 5 that with the increase of fabric weight, thermal insulation value gradually decrease which may be due to the reduction in inter-yarn space and pore size in the test fabric samples. Which reduce the enclosed still air and enhance the contact point of fabric with hot body.

The thermal insulation of the fabrics has good correlation (R= -0.80) with fabric weight as given in Table 8.

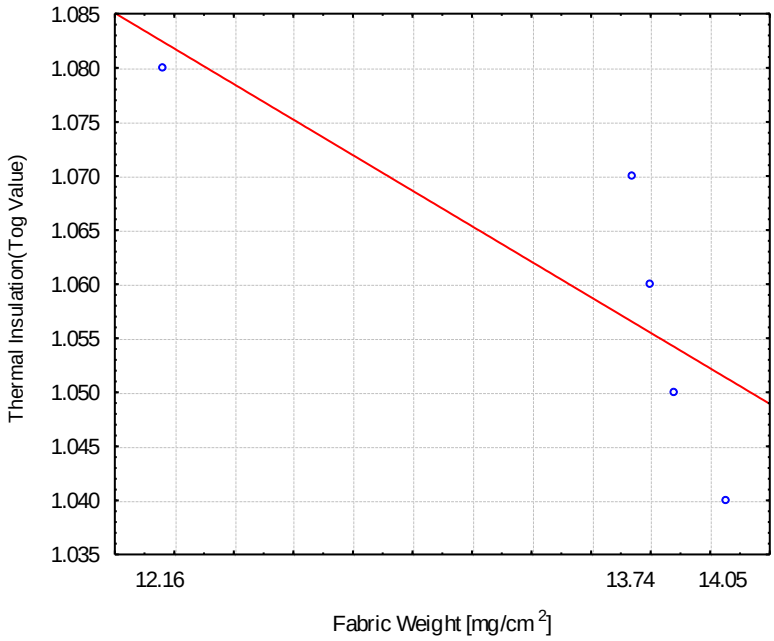

Figure 5 Contour plot of Fabric Weight Vs Thermal Insulation

3.4 Effect of fabric shrinkage on thermal insulation

A graph has been plotted showing the relationship between thermal insulation and fabric shrinkage (Figure 6).

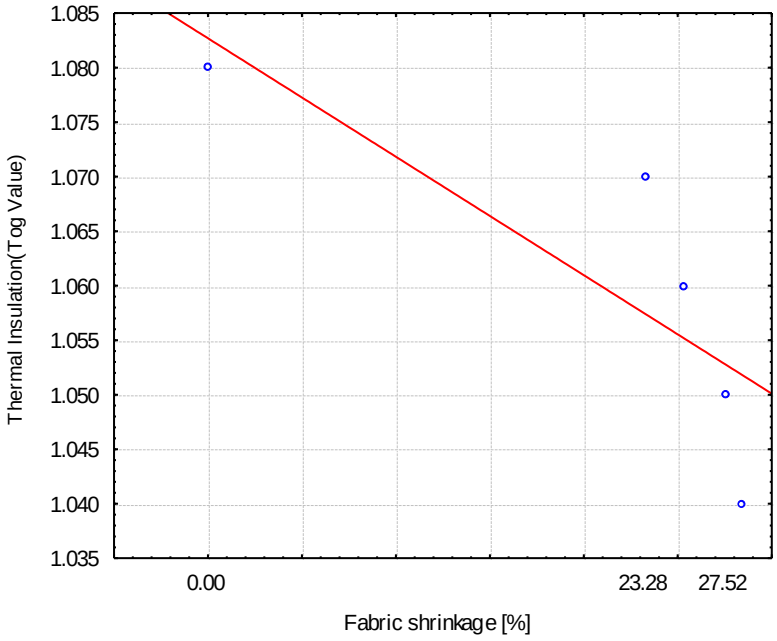

Figure 6 Contour plot of Fabric shrinkage Vs Thermal Insulation

It has been found (Figure 6) that with increase of fabric shrinkage, thermal insulation value found to be decrease which may be due to the decrease in inter yarn porosity and enclosed still air.

The thermal insulation of the fabrics has good correlation (R= -0.81) with fabric shrinkage showing in Table 8.

4. CONCLUSION

From the above study it can be concluded that:

Thermal insulation values of washed sample were decreases after repeated washings. As the values of physical fabric factors i.e. (cover factor, fabric weight and fabric shrinkage) increase the thermal insulation values decrease which may be due the reduction in inter-yarn porosity arising due to the fabric shrinkage. However, in the result the thermal insulation decreases with increase of fabric thickness. This is due to other factors have more influence than thickness like cover factor, fabric weight which reduce the enclosed still air. There are good correlation has been found between thermal insulation and fabric cover factor (R= -97), fabric weight (R= -80) & fabric shrinkage (R= -81).

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