MEASUREMENT AND ANALYSIS OF INTERFACIAL FRICTIONAL PROPERTIES OF SURROGATE SKIN AND TEXTILE MATERIALS

Gopalakrishnan D[1], Dr.P.Kandhavadivu[2]
[1&2] Department of Fashion Technology, PSG College of Technology,
Coimbatore 641 004, India;

Abstract: *A smooth fabric is the one that offers little frictional resistance to motion across its surface and possesses a low coefficient of friction. In view of the diverse nature of fabric surfaces and the fact that normal pressure (load) and frictional resistance are not always directly proportional, the coefficient of friction alone may be insufficient for surface characterization. Friction testing presents challenges due to the sensitivity to variations in the skin-fabric interface. Differing experimental procedures known to affect frictional parameters makes comparisons among published works difficult. A Standard method to measure friction between a fabric and another surface does not exist. However, this instrument does not appear to be widely available. A more common approach is the horizontal platform method, which involves pulling a weighted sled across a fabric adhered to a platform attached to the lower jaw of a tensile tester. A few researches have dealt with the frictional characteristics of fabrics against human skin and skin equivalents relating to the handle properties of apparel fabrics. The New friction test setup named FabFric developed by Department of Fashion Technology, PSG College of Technology, which allows control of load, speed rate, and time. The main aim of this research was to define the effect of friction in the contact zone upon the surface character between fabric and skin equivalents. Tests were performed with four different in loads and time, speed of the probe remains constant. Porcine skin samples were investigated as skin substitute. The results of the investigations confirmed that the load increases with a decrease in the friction coefficient value.*

Keywords: *Skin – fabric friction, Frictional co-efficient, Surrogate skin, Static friction, dynamic friction*

1. Introduction

Differing experimental procedures known to affect frictional parameters makes comparisons among published works difficult. A Standard method to measure friction between a fabric and another surface does not exist [1]. However, this instrument does not appear to be widely available. A more common approach is the horizontal platform method, which involves pulling a weighted sled across a fabric adhered to a platform attached to the lower jaw of a tensile tester [2-6]. A few papers have dealt with the frictional characteristics of fabrics against human skin and skin equivalents relating to the handle properties of apparel fabrics [7-9]. Textile fabrics during their performance experience biaxial deformations, which are effected by friction in the contact zones: material-to-human skin [10-13], material-to-material [14,15], and material-to-inner parts of the furniture: polyurethane or metal. S. N. Jawale *et al* applied lubricant to affect both yarn-to-metal and yarn-to-yarn friction. Ujevic, D. *et al* analysed the uniaxial strength, bursting strength and density of two artificial leathers designed for car seats: artificial leathers with woven and knitted fabrics on the reverse side [17].

2. Instrument

The fabric samples are cut in the size of 3 inches × 3 inches and then it is placed & fixed in the probe (Diameter varies 0.75”, 1”and 2”). The fabric is aligned parallel to contact surface (Fabric/skin/skin substitute/skin alternative/artificial skin/other surfaces). At this moment, the probe sample is about 0.5 cm above the contact sample. The movement of the probe head is controlled by Actuator, run by Main stepper motor with drive. The probe touches the contact material and continues to move downwards until it reaches the maximum pre-load (1grams to 1000 grams) defined to the device at the beginning of the measurement. When the maximum pre-load is attained, the probe stops its vertical movement and following that it starts its second movement which is in prefixed rotating value. The probe stops when the predefined time is reached, which is prefixed, and then the rotating movement starts.

2.1 Skin Equivalent

Pigs have become increasingly important to as models to study human disease and in the testing of new medical devices. Part of the popularity is based on better anatomic similarities to humans as Compared to other large laboratory animals especially with regards to skin. Pigskin is structurally similar to human epidermal thickness and dermal-epidermal thickness ratios. Pigs and humans haves similar hair follicle and blood vessel patterns in the skin. Biochemically pigs contain dermal collagen and elastic content that is more similar to humans than other laboratory animals. Finally pigs have similar physical and molecular responses to various growth factors [17].

3. Effect of chemical pre-treatment on Fabric-skin friction

The four different loads (100, 70, 50 and 30gms) were selected to conduct the coefficient of Friction study. At each load, 5 readings were obtained from different location at same lot of the fabric. The Interlaced warp and weft has been form the contour at the point of interlacements in the plain weave fabric. The floats of yarn were formed elevations and troughs on the fabric structures. At the over laced elevated portion requires extra length of yarn to be used. This is called as crimp of the either warp or weft of the fabric. It shows higher the value of static and dynamic friction is 1.08 and 0.96 as well at the load of 30 grams. Same time the load of 100 grams was 0.32 and 0.29.

Table.3.1. Comparison of effects of Pre-treatment on fabric-skin friction with different loads

Sl.No	sample	Speed (RPM)	Time (Secs)	Coefficient of Friction under various Load levels							
				100 gms		70 gms		50 gms		30 gms	
				μ_S	μ_D	μ_S	μ_D	μ_S	μ_D	μ_S	μ_D
1	Grey sheet	30	20	0.32	0.29	0.39	0.36	0.65	0.54	1.08	0.96
2	Desized	30	20	0.38	0.34	0.40	0.38	0.57	0.52	1.03	0.81
3	Scoured	30	20	0.36	0.31	0.46	0.44	0.49	0.46	0.93	0.85
4	Bleached	30	20	0.36	0.30	0.50	0.42	0.71	0.59	0.93	0.84
5	Mercerized	30	20	0.34	0.32	0.40	0.37	0.56	0.52	1.02	0.94

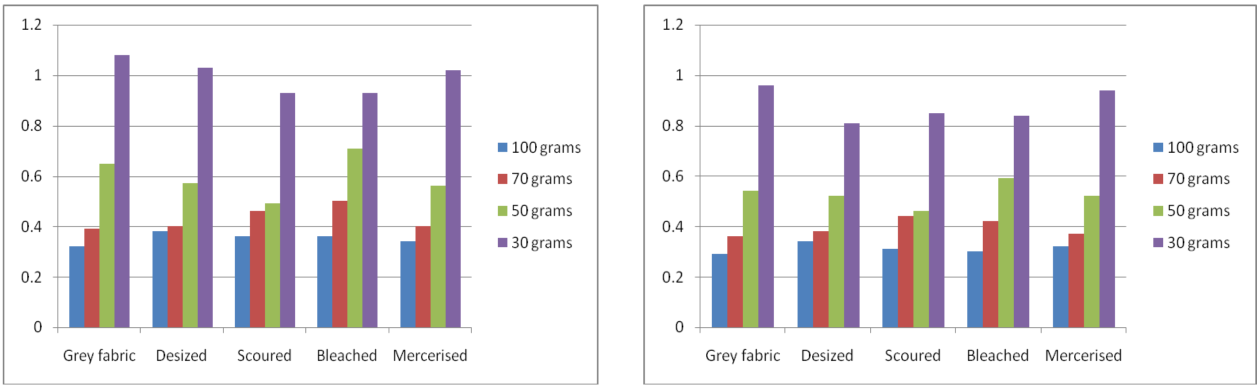

Figure.3.1. Comparison of effects of Pre-treatment on fabric-skin friction (Static & Dynamic) with different loads

3.1 Effect of friction in grey cloth

While grey stage, the fabric should be contain size coated warp yarn. When the fabric get touches and moved over the skin or skin substitute, then the contour of the fabric either trough or floats get flow on the skin grains. Then, the small quantity of force is applied to move the fabric over the skin portions. The sized yarn gets stiffness and smoothness on the surface due to size coat on the warp yarn surface. At the point of contact get reduced where the protruding fibres on the fabric surface. But the sized warp yarn surface gets smoothened and hairy fibres may bind on the yarn surface.

3.2 Effect of desizing

The removal of hydrophobic part of the sizes is often especially problematic. Once it gets removed then the hairy effect may occur. These fibres may reduce the surface contact between fabric and the skin. So that the point of contact will get interrupted due to hairy fibres after desizing. In other case, if the fabric got singed before further treatments, then the fabric has less hairiness and shows more friction when the fabric is in relative motions. In the process of desizing, not only sizing agents, but also some natural impurities are eliminated from fibers. Desizing depends upon the additives used in adhesions between sizing materials and fabric materials, allowing the desizing agent to degrade or solubilized the size material and finally to wash out the degradation products. Dilute acid attacks the polymer chain of starch and due to chain cleavage of starch molecule short water soluble or dispersible chain segments are formed. It affects the surface properties on the fabric and shows static friction of 1.03 and dynamic friction is 0.81 at 30 grams loads. At 100 grams of load affect the friction and shown static friction of 0.38 and dynamic friction of 0.34. In this desizing process the amount of size removed is comparatively greater but it is risky process, due to hydrolytic degradation will occur which fall the strength of cotton. It is not possible to remove all sizing agents during desizing, but is expected to be stabilized or emulsified in the alkaline scouring. The total material present in the cotton fiber is up to 20% of the fiber weight including that of 4-12% natural impurities.

3.3 Effect of Scouring

In the technical aspects, wax content to be reduced on the fibre surface in scouring process. The action of alkaline scouring agent is to saponify any residual oils, to neutralise carboxylic acids, to solubilise any sizing materials and to cause dispersion of naturally occuring impurities in natural fibres. Natural fats, oils and lubricants (tallow) are mostly esters usually in the form of triglycerides. Being triglycerides, the lubricants can be almost hydrolysed by lipases, yielding glycerol, fatty acids and mono-and diglycerides as the reaction product. Glycerol is completely water soluble, fatty acid is removed during scouring and mono and diglycerides are known to be efficient surfactants or emulsifiers. Thus, the treatments improve not only desizing but also the scouring processes. The esters react with sodium hydroxide to form soap and glycerine. The soap thus form can serve as an effective detergent and promote scouring. The unsaponifiable oils are emulsified by the soaps formed during hydrolysis of the saponifiable matter and are easily removed. Wax is difficult to remove. If wax is not removed, non-uniform absorption of dyes and finishing agents will take place. In fact it is the distribution of residual wax after scouring that determines the water absorbency. Pectic acid is insoluble in water but soluble in alkaline solution. Proteins are situated in the central cavity of the fibre and are therefore relatively inaccessible to chemical attack. The proteins and nitrogenous materials are hydrolysed by alkali into soluble amino acids or ammonia. The alkali earth element represents a major variable in cotton fibre and mainly comes from cotton seed husks. It may cause the surface of the fabric and tend to disturb the frictional characteristics of that fabric. The co-efficient of friction shows 0.36 and 0.31 as static and dynamic friction at 100 grams of load. Also have 0.93 and 0.85 of 30 grams of load. Similarly it shows typical changes in 50 and 70 grams of loads too.

3.4 Effect of Bleaching

In bleaching process, Hydrogen peroxide destroys rapidly the colouring particle where it built naturally on the cotton fabric without damage to the fibre from undue oxidative. Intensified bleaching action that to increase commemoration of per hydroxyl ion. The bleaching action at floats and pore areas increase that value with decrease in picks spacing and cause in warp crimp too. Hydrogen peroxide is stable in acidic medium, but bleaching occurs by the addition of alkali or by increased temperature. Hydrogen peroxide liberates per hydroxyl ion (HO^{2-}) in aqueous medium and chemically behaves like a weak dibasic acid. The per-hydroxyl is highly unstable and in the presence of oxidizable substance (coloured impurities in cotton), it is decomposed and thus bleaching action takes place. Sodium hydroxide activates hydrogen peroxide because H ion is neutralized by alkali which is favourable for liberation of O_2. Hydrogen peroxide is a powerful oxidizing agent that rapidly destroys the natural coloring matters present in cotton without undue oxidative damage to the fibers. The effect of alkali, as seen from this equation is to shift the equilibrium to the right to increase the commemoration of per hydroxyl (HO2-) ion, the bleaching agent and hence the bleaching action is intensified. However, peroxide bleached baths with alkali only are unstable and they require stabilizers of inorganic or organic nature. Many of the results revealed that increase of hydrogen peroxide concentration weight loss percentage also increase. After the pre-treatments, the bleached fabric has slight higher coefficient of friction value when compare to the grey fabric. It shows static friction of 0.36, 0.50, 0.70 and 0.93 at 100, 70, 50 and 30 grams of loads. In dynamic frictional values at 100, 70, 50 and 30 grams loads are 0.30, 0.42, 0.59 & 0.84.

3.5 Effect of Mercerisation

In mercerized fabric, most of the values in decreasing trend compared to other with exception of 30gms load. The value is increased. The swelling of cotton fibres is occurred in mercerizing process, it tend to decrease the crimp of the fabric. So that the rougher surface get turn in to smoother and uniform surface. If the fabric may degrade due to chemical then it shows higher the fabric friction. Some other cases mercerization does not bring out any higher changes. But surely the marginal changes occurred by mercerization process. Since concentrated sodium hydroxide (operational solution that includes chemicals) is used in mercerization process, the reactions that take place with the cellulose fibers are intermolecular reactions. That is, the sodium hydroxide that is concentrated this much, penetrates inside the micelles (crystallites) and a structure called hydrate cellulose emerges. Sodium hydroxide reacts with the hydroxyl groups inside the macromolecule in such a way that it either produces sodium cellulosate or it links to the molecules through the pulling forces. When cotton fiber is brought into aqueous solution of sodium hydrose (18%), the cellulose beings to swell immediately and in a few seconds the hair/ fiber is elliptical in X-section. On further swelling, the section rounds off and the major axis of the ellipse is at least 25-30% greater than the fiber width of the corresponding collapsed fiber. The cellulose of the wall swells inwards until the lumen is partially eliminated. These changes are shown in the table 3.1 that deals the frictional changes compared to other treatments. When the fiber is transferred to the water and well washed. Shrinkage beings and on drying at room temperature a further and also final shrinkage occurs. During the last three shrinkage proceeds uniformly towards the center and the lumen does not recover its original size.

4. Conclusion

The effects of friction in the contact zone upon the surface character between fabric and skin equivalents are measured with different pre-treated fabrics. Tests were performed with four different in loads and time, speed of the probe remains constant. Porcine skin samples were investigated as skin substitute. The results of the investigations confirmed that the load increases with a decrease in the friction coefficient value. The pre-treatment has influenced directly due to the structural and surface changes at treatment process. The p-value corresponding to the F-statistic of ANOVA is higher than 0.05. In static friction, F-statistic is 0.0169, p-value of 0.9994 and Mean standard deviation is 0.0598. For dynamic friction, F – statistics of 0.0105, p-value is 0.9998 and Mean standard deviation of 0.0507. Multiple comparison tests, in some instances, a small set of pairs might show significance.

5. References

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