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Analysing the Effect of Decatising on the Frictional Properties of Wool Fabrics

Abstract
The properties of wool fabrics desired can only be achieved if appropriate finishing processes are carried out. Decatising is a part of wool finishing processes increasing the fabric surface properties of fabrics. In this study, high pressure decatising process was applied to semi-decatised woven wool fabrics. Surface properties (coefficient of friction, mean deviation in the frictional force, geometric roughness) of the fabrics were measured by KES-FB4, and the friction coefficient of the fabrics by means of a Frictorq test machine before and after application of the high pressure decatising process. The effect of high pressure decatising on the fabric surface properties of wool and wool blend fabrics was analysed. It was concluded that high pressure decatising process had a healing effect on the fabric surface properties, and also the coefficient of friction and surface roughness values decreased.

Key words: *wool fabric, decatising process, surface properties, frictional coefficient, handle.*

Introduction

The frictional properties including friction coefficient of wool fabrics are highly important components of subjective handle assessment. The quality and surface characteristics of wool fabrics can be evaluated by handle evaluation methods. Finishing is a series of processes to develop the properties of wool fabrics and different combinations of wet and dry finishing processes are applied to wool fabrics to improve the handle and mechanical properties of the fabrics. Decatising is a normal finishing step for many wool and wool blend fabrics. High pressure decatising is an effective mechanical softening treatment resulting in lustrous, soft and smooth handle [1].

In the semi-decatising process, wool fabric is wound onto a perforated drum between interleaving cotton blankets. Steam is sent through the perforated drum for several minutes to ensure moisture and heat. The controlling time, pressure, heat, moisture and cooling result in effective mechanical softening and better surface properties like luxurious, softness and smooth handle [2].

High pressure decatising is one of the finishing processes that permanently sets the thickness and relaxed dimen-

Figure 1. *KES-FB4 automatic surface tester [16].*

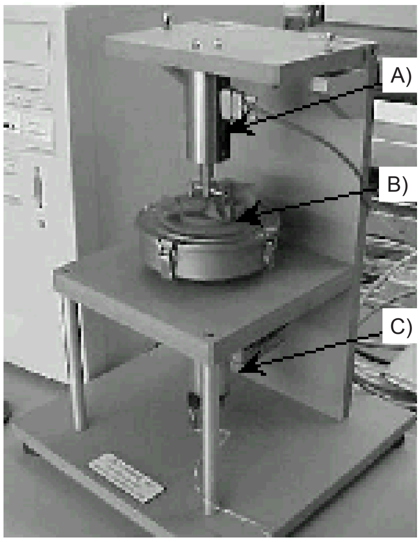

Figure 2. *Frictorqtest device [17]; A) tarque sensor, B) fabric sample, C) drive motor.*

Table 1. *Characteristics of fabric samples.*

Sample No.	Material type	Fabric area weight, g/m2	Process
1	100% Wool	165.74	Semi-Decatising
2		170.19	High Pressure Decatising (H.P.D)
3	70%Wool-30%PET	194.55	Semi-Decatising
4		198.12	High Pressure Decatising (H.P.D)
5	75% Wool-25%Silk	171.42	Semi-Decatising
6		177.96	High Pressure Decatising (H.P.D)

sions of wool fabric. It also increases the surface smoothness and handle properties of wool fabrics. In this process wool fabric is interleaved with a cotton or cotton/synthetic wrapper, at a regain usually between 5 and 15%, and wound into a batch on a hollow perforated cylinder in an autoclave (pressure vessel) with steam greater than atmospheric pressure. The direction of steam flow can usually be varied from outside-to-inside or alternatively inside-to-outside, whereby both the cohesive and permanent sets are introduced into the fabric. After purging with steam to remove air, the roll is steamed under pressure for up to five minutes at temperatures between 105 and 130 °C. The fabric and wrapper are then cooled by drawing air at ambient temperature through the roll. The amount of permanent sets introduced depends on the fabric pH, the time of treatment, the temperature and relative humidity of the steam and on the regain of the fabric [3].

Researchers, beginning with Pierce, noticed the need for quantitative assessment of handle in 1930 [4]. Kawabata related the handle value with 16 mechanical properties that can be measured with 5 different instruments providing a valuable basis to make an objective assessment, especially making comparisons [5]. The Kawabata Evaluation System (KES-FB) is based on discrete test instruments for measuring tensile, shear, bending, compression and surface properties, which are the basis for the expression of fabric handle. During the surface test of KES (FB-4), two contact sensors measure the thickness variation of the sample and frictional force. Surface roughness and the coefficient of friction are given at the end of the test. A higher coefficient of friction value (MIU) indicates higher fabric friction, while a higher surface roughness value (SMD) indicates a rougher (less smooth) fabric surface [6].

Lima et. al. used the instrument Frictorq to compare the friction coefficient in nonwovens applied for non-active medical devices, and they concluded that frictorq measurements could be used as a comfort parameter because information related with tactile perception was obtained [7]. Also Lima et. al. analysed and compared the friction coefficient of three different double-faced fabrics made from non-conventional fibre combinations [8]. Thorndike and Varley researched the frictional properties of fabrics in relation to handle [9]. Owen proposed eight physical properties, which are stiffness, weight, thickness, compressibility, liveliness, ease of skewness, shearing and cold feeling, as important factors involved in handle [10].

Finnimore carried out different finishing processes for 100% wool knitted and woven samples and found out that pressure decatising was the most important step for fabric handle [11]. Finnimore further

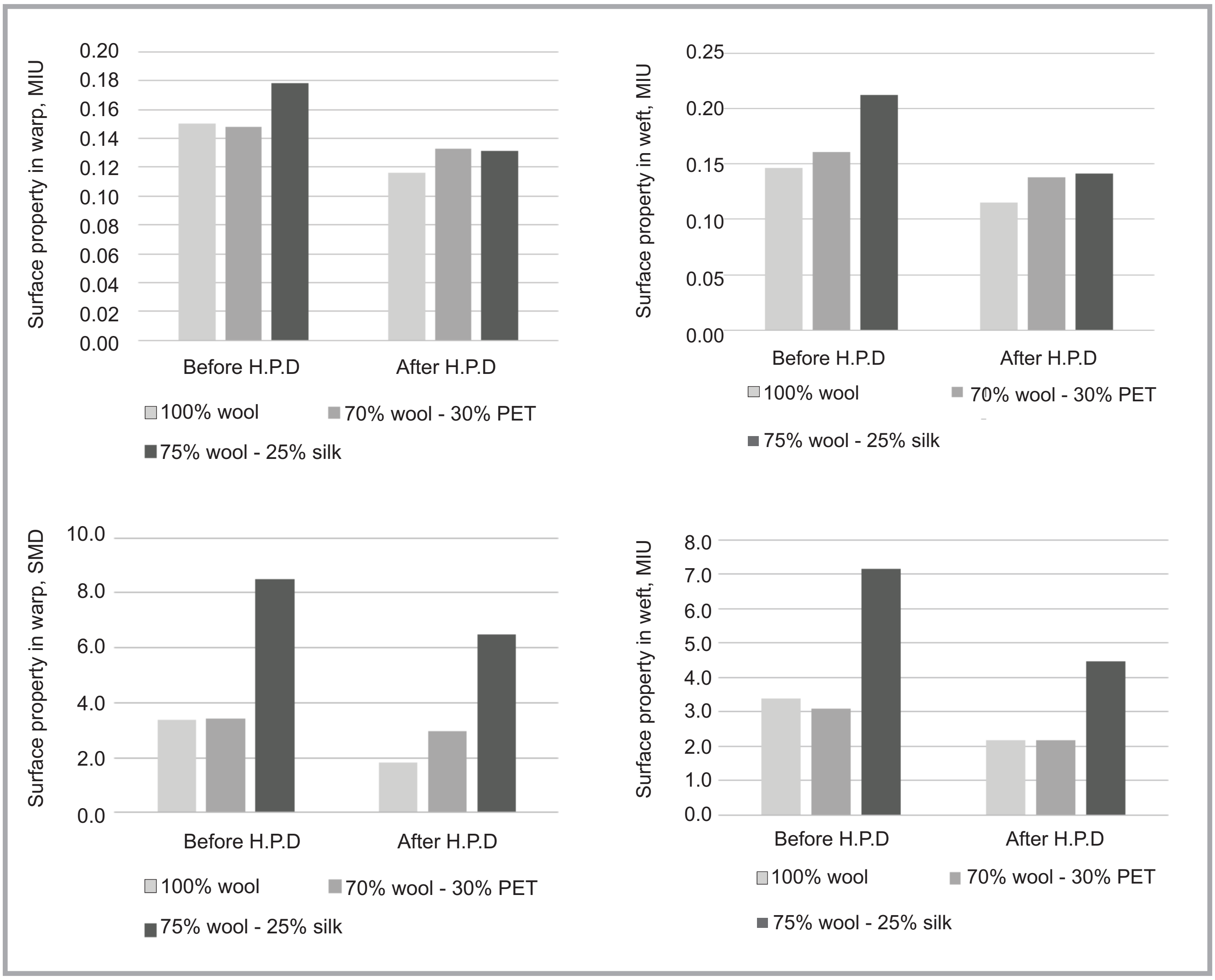

Figure 3. *Comparison of surface properties of fabrics before and after high pressure decatising.*

found out that during decatising, fabric thickness decreased and yarns were flattened, which could lead to an increased contact area between yarns and, hence, an increase in shear rigidity obtained. De Boos et. al. researched the effect of semi-decatising, crabbing, scouring, heat setting, dyeing, final pressing and pressure decatising on men's suit fabrics, which are wool and wool blends [12]. They reported that the more effective the setting treatment, the greater the change in bending rigidity, residual curvature and thickness were, but the heat setting had little effect on the ultimate bending rigidity of the fabric pressed, especially after pressure decatising.

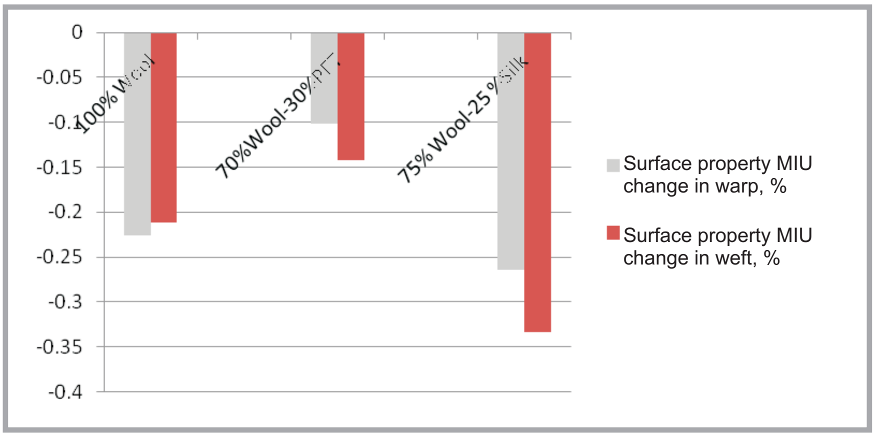

Figure 4. Changes in the surface properties of samples after the application of high pressure decatising.

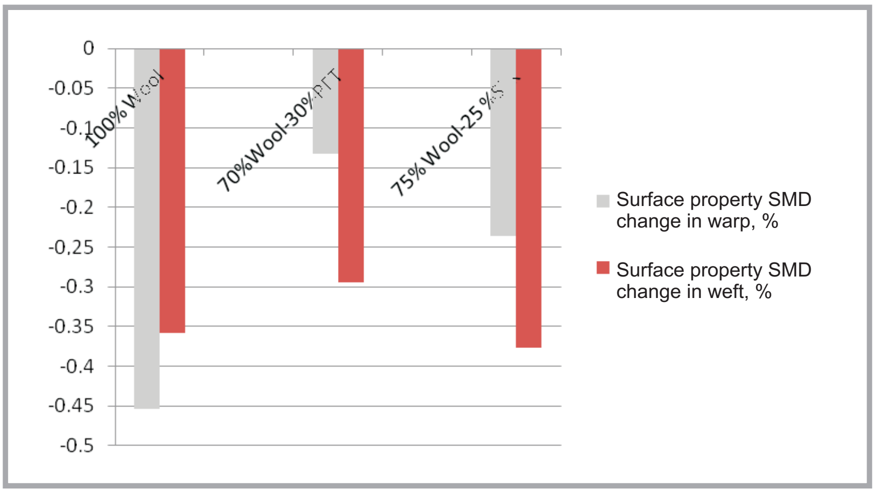

Figure 5. Changes in the surface properties of samples after the application of high pressure decatising.

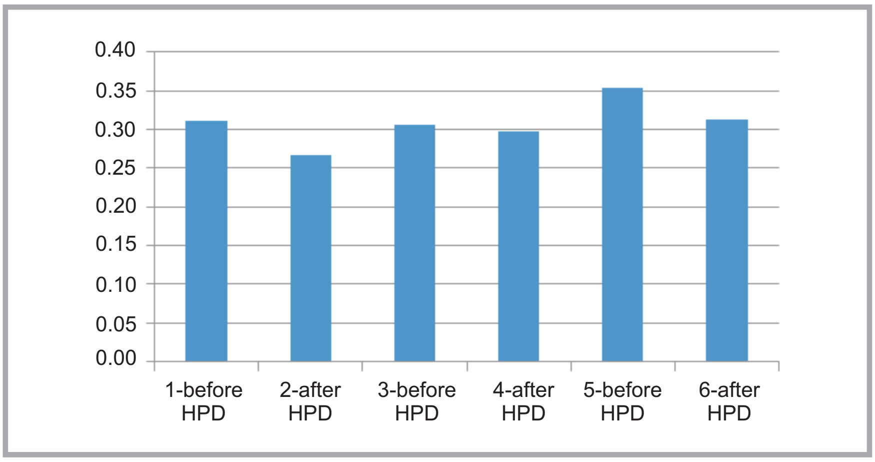

Figure 6. Frictorq test results (μ max).

Table 2. Frictorq test results.

Sample	Max torque, cNm	Min torque, cNm	N° data points
1-Before HPD	0.339	0.320	792
2-After HPD	0.291	0.281	793
3-Before HPD	0.333	0.311	791
4 After HPD	0.325	0.302	792
5-Before HPD	0.386	0.355	801
6-After HPD	0.340	0.318	792

Dhingraet. al. studied the effects of weaving on the heat setting, scouring, blowing, paper pressing and pressure decatising. They showed that there was a slight reduction after scouring in both the shear rigidity and shear hysteresis values, while the highest compressibility was observed in the pressing process [13]. Lin et. al. treated floss silk by scouring and finishing, tested the mechanical and surface properties by an Instron 5566 tensile tester, and the crystal structure was analysed with FTIR [14]. They found that the fibre surface becomes much smoother after the scouring agent degumming treatment. Hasaniet. al. researched and compared low-stress mechanical properties, such as tensile, shear, bending, compression, and surface properties, measured by the Kawabata Evaluation System for Fabrics (KES-FB), of polyethylene terephthalate (PET) and poly(lactic acid) (PLA) fabrics before and after softening with commercial softeners [15].

In this study, in order to measure and compare the handle properties of wool fabrics, the high pressure decatising process and semi-decatising processes were applied. The handle properties of fabrics were evaluated before and after the application of high pressure decatising. Surface properties of the fabrics were measured using KES-FB4 and Frictorq instruments. In this study, the effect of high pressure decatising on the surface properties of semi-decatised and high pressure decatised wool fabrics were analysed and compared.

Experimental

Objective evaluations were made by using a KES-FB4 Automatic Surface Tester, as seen in ***Figure 1***. The instrument measures fabric surface properties which are closely related to the handle feeling of fabrics. The fabric friction coefficient

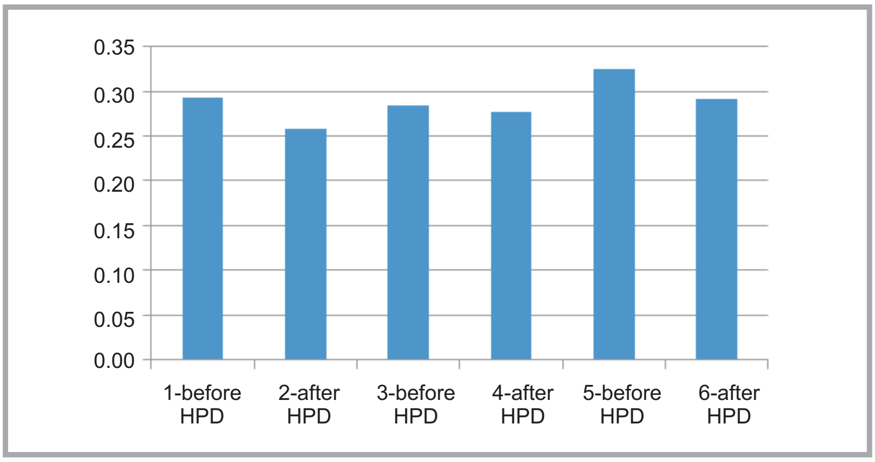

***Figure 7.** Frictorq test results (μ kinetic).*

***Table 3.** Paired samples T test correlation results in relation to the process changing from semi-decatising to high pressure decatising.*

Paired sample	N	Correlation
Pair 1 MIU-M Warp & process		-0.822
Pair 2 MIU-M Weft & process		-0.694
Pair 3 SMD-M Warp & process		-0.290
Pair 4 SMD-M Weft & process	6	-0.470
Pair 5 μ max & process		-0.604
Pair 6 μ kinetic & process		-0.629
Pair 7 Max Torque & process		-0.605
Pair 8 Min Torque & process		-0.630

***Table 4.** Hypothesis tests results in relation to the process changing from semi-decatising to high pressure decatising.*

Paired sample	Paired differences					t	df	Sig. (2-tailed)
	Mean	Std. deviation	Std. error mean	95% confidence interval of the difference				
				lower	upper			
Pair 1 MIU-M Warp - process	-1.357	0.565	0.231	-1.951	-0.764	-5.881		0.002
Pair 2 MIU-M Weft - process	-1.348	0.571	0.233	-1.947	-0.749	-5.782		0.002
Pair 3 SMD-M Warp - process	2.933	2.731	1.115	0.067	5.800	2.631		0.046
Pair 4 SMD-M Weft - process	2.245	2.188	0.893	-0.052	4.542	2.513		0.054
Pair 5 μ max - process	-1.192	0.565	0.231	-1.785	-0.599	-5.168	5	0.004
Pair 6 μ kinetic - process	-1.212	0.562	0.229	-1.801	-0.622	-5.281		0.003
Pair 7 Max Torque - process	-1,164	0.567	0.231	-1.759	-0.570	-5.032		0.004
Pair 8 Min Torque - process	-1.185	0.563	0.230	-1.777	-0.591	-5.154		0.004

***Table 5.** Paired samples T test correlation results with respect to material type.*

Paired sample	N	Correlation
Pair 1 MIU-M Warp& material type		0.451
Pair 2 MIU-M Weft& material type		0.626
Pair 3 SMD-M Warp& material type		0.869
Pair 4 SMD-M Weft& material type	6	0.719
Pair 5 μ max & material type		0.704
Pair 6 μ kinetic& material type		0.663
Pair 7 MaxTorque & material type		0.704
Pair 8 MinTorque & material type		0.663

and mean deviation of the coefficient of friction are detected by the friction contactor, which is directly connected to a frictional force transducer. Geometrical surface roughness is detected by the contactor for roughness. All of the parameters measured can be obtained directly from the calculation circuit of the instrument. ***Figure 2*** also shows the frictorq test apparatus.

Fabric sample characteristics used in this study are shown in ***Table 1***.

The surface friction of the fabrics was measured by a FRICTORQ device. Frictorq is based on a rotary movement and measurement of the friction reaction torque [18]. The principle is based on an annular shaped upper body rubbing against a flat lower fabric. The fabric sample is forced to rotate around a vertical axis at a constant angular velocity. The friction coefficient is then proportional to the torque measured by means of a high precision torque sensor.
The results of the experiments were analysed using the IBM SPSS Statistics 20 programme.

Results

Surface properties of the samples measured are shown in ***Figures 2, 3, 4*** and ***5***. The MIU value indicates the coefficient of friction and the SMD value - the surface roughness. During the surface property evaluation, the difference between after the high pressure decatizing (HPD) and before high pressure decatising (HPD) processes was calculated.

As is seen in ***Figure 3***, after the application of high pressure decatising, the surface properties of all fabrics become better. Surface roughness and fabric friction values of these fabrics decreased and resulted in better fabric handle.

Figures 4 and ***5*** show the change in surface properties of samples after the application of high pressure decatising. The change in the surface properties of 100% wool fabrics in the warp direction is more than in the weft direction. On the other hand, for both fabrics, 70% wool-30% PET fabrics and 75% wool - 25% silk, the change in the surface property in the weft direction is more apparent than in the warp direction.

Figures 6, 7 and ***Table 2*** show test results of all samples measured by the Frictorq test device.

It is seen in ***Figure 5*** that after high pressure decatising application, there was a decrease in the coefficient of friction values for all fabric surfaces. Moreover the μ kinetic coefficient of friction values decreased after the application of high pressure decatising, as shown in ***Figure 7***.

Table 6. Hypothesis tests results with respect to material type.

Paired sample	Paired differences					t	df	Sig. (2-tailed)
	Mean	Std. deviation	Std. error mean	95% confidence interval of the difference				
				lower	upper			
Pair 1 MIU-M Warp - material type	-1.857	0.885	0.361	-2.786	-0.929	-5.141	5	0.004
Pair 2 MIU-M Weft - material type	-1.848	0.874	0.357	-2.765	-0.931	-5.177		0.004
Pair 3 SMD-M Warp - material type	2.433	1.800	0.735	0.545	4.322	3.312		0.021
Pair 4 SMD-M Weft - material type	1.745	1.381	0.564	0.295	3.195	3.094		0.027
Pair 5 μ max - material type	-1.692	0.875	0.357	-2.610	-0.774	-4.738		0.005
Pair 6 μ kinetic - material type	-1.712	0.880	0.359	-2.635	-0.788	-4.765		0.005
Pair 7 MaxTorque - material type	-1.664	0.873	0.356	-2.581	-0.748	-4.669		0.005
Pair 8 MinTorque - material type	-1.685	0.879	0.359	-2.607	-0.763	-4.699		0.005

Analyses were conducted using the paired-samples T test procedure with a significance level of $\alpha = 0.05$, the results of which obtained are shown in ***Table 3***. There was a negative correlation between the values analysed and the processes (Semi-Decatising and High Pressure Decatising). SMD-M Warp& process and SMD-M Weft& process values attained low correlation coefficient values according to the process but other pairs achieved good levels of correlation coefficients. In ***Table 4*** it is seen that the values of significance levels are less than 0.05, which means that there is a significant difference in the MIU-M warp, MIU-M weft, μ max, μ kinetic, max torque and min torque values according to the processes, changing from the Semi-Decatising process to the High Pressure Decatising process.

The paired-samples T test procedure was also used to test the hypothesis in relation to material type. As the material type changes (100% wool, 70% wool - 30% poliester, 70% wool - 30% silk) it was found that there was a positive correlation between the values measured and the material type (***Table 5***). Moreover it is seen in ***Table 6*** that significance levels are less than 0.05, meaning that there is a significant difference in the MIU-M warp, MIU-M weft, μ max, μ kinetic, max torque and min torque values in relation to the material type.

*Table 7. Correlation coefficients of KES-FB and Frictorq; ** Correlation is significant at the 0.01 level (2-tailed).*

Variables	Pearson correlation
MIU-M warp - μ max	0.927**
MIU-M weft - μ max	0.938**
MIU-M warp - μ kinetic	0.930**
MIU-M weft - μ kinetic	0.930**

Also, ***Table 7*** shows that the coefficient of friction values obtained from KES-FB and Frictorq also parallel each other.

Conclusions

In this study, the effect of high pressure decatising on the fabric surface properties of wool and wool blend fabrics were analysed. It was concluded that high pressure decatising has a changeable effect on the fabric surface properties. Surface properties are also closely related to the handle and surface smoothness of the wool fabrics. Decatising imparts a cohesive set to fabric and is used to reduce fabric thickness and increase surface smoothness.

According to our results, for all the types of fabrics, the coefficient of friction of the surfaces and surface roughness values decreased after the high pressure decatising process. After the decatising process both the coefficient of friction and geometric roughness values decreased significantly. These findings also parallel those of Dhingra et al, Finnimore and Ajayi [11, 13, 19]. Furthermore it is seen that the coefficient of friction values obtained from KES-FB and Frictorq also parallel each other, as shown in the study of Lima et. al [18].

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