EFFECTS OF ULTRASONIC WASHING ON COTTON TEXTILES

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Abstract: *The idea of employing ultrasonic energy to textiles has been commenced since 1990s. It can be seen that the use of ultrasonic energy in textile washing processes has some advantages such as energy conservation, reducing the duration of the processes, and improving the parameters of the product quality. For this reason, ultrasonic energy can be an alternative to conventional washing methods. More recently, ultrasonic energy has been used on the dyeing of cellulose nanofibres. However in generally, researchers have been used ultrasonic energy on the wet finishing processes rather than the effects of mechanical properties of the yarns.*

In this work, we aimed to study the mechanical properties of the cotton textiles after being washed with the help of ultrasonic energy. 100% cotton yarns and knitted fabrics produced from these yarns were washed by both ultrasonic and conventional methods. The two techniques were compared in terms of yarn breaking strength, yarn breaking elongation, pilling of fabrics and lightness (L) values of the fabrics. The results showed that ultrasonic washing can present slightly higher mechanical properties than the conventional washing of the cotton yarns. It was observed that ultrasonically washed fabrics have better pilling values than the conventionally washed fabrics. Cotton fabric appearances were also examined under JEOL-JSM 5910 LV model scanning electron microscope.*

Key words: *Ultrasonic energy, conventional washing, pilling, cotton, tenacity, SEM.*

1. INTRODUCTION

Textiles can be in various forms i.e. loose fibres, spun and filament yarns, fabrics or non-woven materials. Even though a particular form of the material may state the type of machinery best can be used on an industrial scale, it is the nature of the fibre itself that determines the procedure to be used. Amongst textile technologies, numerous methods have been established and used to improve the properties of cotton yarns and textiles; ultrasonic energy is one of that methods where is applied in textiles. The ultrasonic energy has been adapted to textiles in wet finishing processes, almost the past twenty years; yet in all these works ultrasonic energy was generally applied to dyeing of textiles [1],[2],[3],[4],[5]. In some studies, the utility of ultrasonic methods has been considered in regards of the dyeability properties of bleached cotton yarns and woven fabrics, medical surgery gowns were successfully washed and cleaned with ultrasonic energy where the fabrics treated by ultrasonically have shown less tenacity when compared to fabric treated by conventional methods [6],[7],[8],[9]. Recently ultrasonic energy technique was applied to wool dyeing process where wool woven fabrics were dyed well with the ultrasonic probe by reducing the amount of time more than an hour than the conventional dyeing technique [10]. Also the ultrasonic energy has been used for removing undesirable materials on textiles and improving effectiveness of enzyme molecules [11]. In another study, conventionally washed fibres within the cotton yarns were extensively deformed and it was thought that this is due to the changes between the distances of fibre macromolecules where evident [12]. The aim of this study was to wash cotton yarn and fabrics by means of ultrasonic energy and compare their mechanical properties with those washed by a conventional method. In this study, both conventional washing and ultrasonic washing methods reduced the breaking tenacity of yarns. However, ultrasonic washing method caused less loss of breaking tenacity than conventional washing method. It is expected that the textile industry will benefit more from the ultrasonic energy on a commercial scale.

2. MATERIALS

2.1. Yarn Samples Production

In this study, 15 tex cotton ring-spun yarns were produced with a twist factor of α_{tex} 31.5. All of the yarns were tested in standard atmospheric conditions (20 ± 2 ^{0}C and 65% ± 2 RH) after 48 hours of equilibrium was reached. Fibre properties were measured on the SPINLAB HVI 900 instrument; yarn evenness and hairiness were both measured on the Uster Tester 3. The properties of fibres and yarns are given in Tables 1 and 2 respectively.

Table 1: *Fibre properties*

Fibre properties	
Micronaire	4.7
%50 spun length (mm)	26.7
%2.5 spun length (mm)	30.5
Strength (g/tex)	33.8
Elongation (%)	7.7
Rd	76.7
+b	8.4
Colour grade	31-2

Table 2: *Yarn properties*

Yarn properties	
Yarn linear density (tex)	15
Twist factor (α_{tex})	31.5
Yarn irregularity (U %)	11.1
Hairiness (H)	5.4

2.2. Fabric Production

To determine the effect of washing technique on the pilling of fabrics, the cotton yarns were knitted into a stocking fabric on a Harry Lucas machine (E 20 and total of 240 needles).

2.3. Detergent

In this study, 1g/L commercial detergent was used. The content of this detergent is:
‹5% nonionic active, polycarboxysilicate, phosphanate, soap, cation active substance,
5-15 % anionic active, oxygen-based bleaching,
15-30 % phosphate and enzyme.

2.4. Methods

2.4.1. Ultrasonic Washing Method

In this study, Branson 2200-F-4 model ultrasonic cleaner (47 kHz ± 6%) was used in the ultrasonic washing. 1L of deionised water containing 1g of commercial detergent placed in an ultrasonic bath. 600 mm long cotton yarns and 150x150 mm squares of knitted fabrics were immersed into heated bath. The yarns and fabrics were kept for 30 min durations in the ultrasonic vibrated bath at 40 ^{0}C of water. The ultrasonic washing process was repeated 10 times for each sample. After the washing process, the ultrasonically washed samples were rinsed twice in a 1l deionised water bath and left out to dry at room temperature.

2.4.2. Conventional Washing Method

1L of deionised water containing 1g of commercial detergent was placed into a Gyrowash lab-size washing machine. Temperature was maintained at 40 ^{0}C throughout the washing. 600 mm long cotton yarns and 150x150 mm squares of knitted fabrics were placed in the machine and washed for 30 min intervals. After being washed 10 times repeatedly, the samples were rinsed twice in a 1l deionised water bath and left out to dry at a room temperature.

2.4.3. Determination of Pilling Washing Method

The fabric samples were left to conditioning under the standard atmosphere which is 20 ± 2 ^{0}C and 65% ± 2 RH for 48 hours. 4 samples from each fabric were tested for pilling on a nu-martindale abrasion tester. 2000 rubs were considered for the pilling tests and the comparison was made according to ASTM D 4970-89 (12).

2.4.4. Mechanical Testing

Both conventionally and ultrasonically washed yarns were tested for their breaking tenacity and elongation according to ASTM D 2256-97 standard [13] by using a Instron 4411 model testing instrument. The mechanical testing instrument was calibrated just prior to the tests according to the instructions given in the equipment's manual. All the yarns were tested in standard atmospheric conditions after 48 hours of equilibrium was reached.

2.4.5 Colour Measurement of the Washing Samples

The colour of untreated fabric, ultrasonically washed and conventionally washed fabrics was measured using a Datacolor SF 600 PLUS spectrophotometer with the CIELab system D 65 and 10^0 observer USAV 6.6 mm.

2.4.6. Evaluation of the SEM Photographs

In this study, a JEOL JSM-5910 LV model scanning electron microscope was used. Samples of untreated cotton fabrics, fabrics washed in conventional method and fabrics washed by ultrasonic method was cut into small pieces and bonded onto a conductive mount. These samples were then gold coated for 90 seconds with 18 mA current under vacuum. The magnification was 25 kW with x60.

3. RESULTS AND DISCUSSION

3.1. Pilling Values of the Produced Fabrics

The pilling values of the cotton knitted fabrics are given in Table 3; the related standard [14] gives pilling values of the fabrics as 1, 2, 3, 4, 5 from the worst to the best.

Table 3: *Pilling values of knitted fabrics*

Fabrics	Pilling values of untreated fabric	Pilling values after ultrasonic washing	Pilling values after conventional washing
Coton (100 %)	3	4	3

3.2. Breaking Tenacity and Breaking Elongation Values of the Yarns

As can be seen in the tables, both ultrasonic washing and conventional washing methods resulted in a decrease in yarn breaking tenacity values with respect to unwashed cotton yarns. However, when the two washing methods were compared to one another it is obvious that ultrasonic washing method caused less deterioration in breaking tenacity of yarns than conventional method. Due to the discrepancies in the values of yarn elongation, the situation seems to be not very clear in the case of the elongation values. But again ultrasonic washing method gave rise to higher elongation values compared with conventional washing method. It is thought that by the interlocking effect, the fibres were reduced leading to an increase in the elongation values. The yarn tensile parameters are tabulated in Table 4.

Table 4: *Yarn tensile parameters*

Yarn Parameters	Untreated Yarn	Sd	Washed by Ultrasonic Method	Sd	Washed by Conventional Method	Sd
Yarn Breaking Tenacity (cN/tex)	14.5	0.53	13.8	0.49	13.0	0.51
Yarn Breaking Elongation (%)	4.10	0.46	3.40	0.52	3.20	0.48

3.3. Lightness (L*) Values of the Fabrics

The results of these colour measurements are presented as lightness (L*) in Table 5. As can be seen in the table, conventional washing method resulted in lower lightness (L*) values than that of ultrasound process.

Table 5: *Lightness (L*) values of the fabrics*

L* Values of Untreated Fabric	L* Values after Conventional Washing	L* Values after Ultrasonic Washing
83.99	87.00	88.58

3.4. Interpretation of the SEM Photographs

Ultrasonic washing led to less reduction in yarn strength when compared with conventional washing. The reason for this is superior performance of that the cavitation energy, which is formed by ultrasonic vibration, was evenly distributed among fibres. This was demonstrated by the SEM micrographs shown in the Figs 1–3. In these micrographs, the yarn twists can be clearly observed on the ultrasonically washed fabrics. In the comparison of ultrasonic washing with conventional washing, less harm was demonstrated to the yarns of the fabrics. As mentioned earlier, the protruding ends of the fibres were visualized through scanning electron microscopy on the fabric surface to correlate a relationship with number of these ends of the yarns and surface of the knitted fabrics which are made of from these yarns.

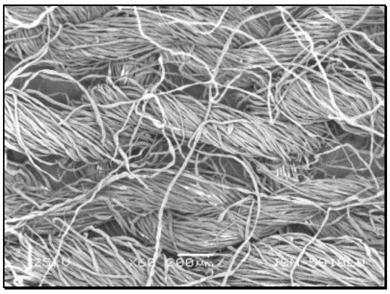
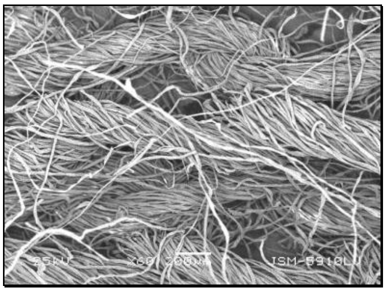
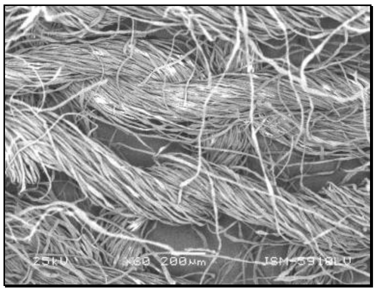

Fig.1: *Untreated fabric* ***Fig.2:*** *Conventionally washed fabric* ***Fig.3:*** *Ultrasonically washed*
fabric

3. CONCLUSION

1. The breaking tenacity and elongation of washed and dried yarns were lower than the untreated yarns.
2. Both breaking tenacity of yarns and elongations were slightly lower than the ultrasonic washing methods.
3. Better lightness (L*) can be achieved by using the ultrasonically washed knitted fabrics than by using a conventional washing method.
4. Ultrasonically washed fabric has shown better pilling values than conventionally washed fabrics.
5. Conventionally washed fabrics have shown more protruding ends on the surface of the knitted fabrics than the ultrasonically washed fabrics.

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