A New Approach For Wrinkle Recovery Evaluation of Worsted Fabrics Using Fuzzy Systems.

E. Hezavehi*
Textile Engineering Department, Arak Campus, Islamic Azad University, Arak, Iran
S.Sheikhzadeh Najar
Textile Engineering Department, Amir Kabir University, Tehran, Iran
Sh. Hoseini Hashemi
Mechanical Engineering Department, Iran University of Science and Technology, Tehran , Iran
A. Rashidi
Textile Engineering Department, Science and Research Campus , Islamic Azad University, Tehran, Iran
B. Asadi
Mathematical Department, Arak Campus, Islamic Azad University,Arak, Iran

Abstract

In present study, designing and fabricating a device similar to wrinkle recovery AATCC 128, and using microcontroller and computer, various torsional strains imposed to the fabric and the fabric wrinkle force was measured using a load cell.
An stepper motor and screw shafts with different pitches were used to impose various strains on the fabric. Then the fabric surface changes in both direction of weft and warp were examined using image processing .Dimensional changes results in weft and warp directions were considered as (S_1/S_2) to represent input criteria to fuzzy model.

The results of this research revealed that fabric samples with higher polyester fiber content exhibited, better wrinkle recovery and less wrinkling.. According to the model of fuzzy, fabric wrinkling and deformation can be classified according to there properties and in this way the classes of fabrics can be determined.

Key Words: Torsional strain, Fuzzy system, wrinkle, Microcontroller.

Introduction

The buckling, bending, drape, wrinkle behaviors of a woven fabric influence its performance during actual use and during the process of making-up into the end product. These properties are important, particularly when the fabric is limp, resulting in large-scale deformation even under small applied forces [1,2].By using AATCC machine the mechanism of creating wrinkled fabrics starts. In this operation, the fabric forms as a tube shell and two edge warp round the two flanges. Then a 3.5 Kg weight sets above the upper flange which is movable. Therefore,the upper flange by using a pilot bar rotates 180 degrees and rolls downward. This operation causes the fabric wrinkles and because of fabric properties, the fabric after the deformation returns to the primary state and also according to atmospheric standard conditions regarding to five wrinkled standard samples (replica), the fabric will classified by experts [4,5]. The most important weakness of this method is that because this

*Corresponding Author

method is done mentally and visually and when the place of spicements wrinkle is so close to each other, the estimating shall be encountered with problem by experts. For this reason, other method for example using Image processing [6,7,8,9], neural networks [10,11] laser probe [12] and have been used which reduce human fault rates in wrinkle estimating ; that the common working base of these methods are based on surface elevation changes fabric surface 3Dchanges and wrinkle density. Fuzzy theory was founded by zadeh [2] in 1965 as the theory of fuzzy sets in contrast to the classical approach of common (crisp) sets. Common set theory is based on the concept that any given item is or is not a member of a set, e.g. an element is either a metal or a non-metal . fuzzy sets allow for degrees of set membership (e.g germanium both is and is not a fabric) and this concept often matches the real world much better than crisp definitions. Wrinkle; there are many uncertain statements such as wrinkle recovery of a cloth. In this paper we try to select the worsted fabric with different percent of wool mixture, polyester and applying various torsional strains (unlike the AATCC method) on the basis of surface change in fabric surface by use of image processing and fuzzy algorithm, estimating the wrinkle behavior and fabric wrinkle amount.

Fuzzy Arithmetic

Let A be a fuzzy number, i.e. a convex normalized fuzzy subset of the real line in the sense that :

a) $\exists X_\circ \in R \ and \ \mu_A(\chi_\circ)=1, where \mu_A(\chi)$ is the membership function specifying to what degree χ belongs to A;

b) μ_A is a piecewise continuous function

The α-level set of A is the set

$A_\alpha = \{\chi \in R \mid \mu_A(\chi) \geq \alpha\}$

where $\alpha \in (0,1]$.

The lower and upper bounds of any α -level set A_α are represented by $\inf\{\chi \mid \chi \in A_\alpha\}$ and $sup\{\chi \mid \chi \in A_\alpha\}$ and we suppose that both are finite.

A function, usually denoted by "L" or "R" , is a reference function of a fuzzy number which is defined as

$$\mu_A(\chi)=\begin{cases} L\left(\left(A^L-\chi\right)/\alpha\right) & if \quad \chi \leq A^L, \alpha>0, \\ R\left(\left(\chi-A^U\right)/\beta\right) & if \quad \chi \geq A^U, \beta>0, \\ 1 & otherwise, \end{cases} \quad (1)$$

Where $A^L < A^U$, $[A^L, A^U]$ is the core of A , $\mu_A(\chi)=1, \forall\chi \in [A^L, A^U]$, A^L, A^U are the lower and upper model values of A and $\alpha>0$, $\beta>0$ are the left-hand and right-hand spreads [3].

More briefly, a flat fuzzy number is denoted by $A=[A^L, A^U, \alpha, \beta]_{LR}$

Among the various type of L-R flat fuzzy number, trapezoidal fuzzy number. Denoted by $A=(A^L, A^U, \alpha, \beta)$, are of the greatest importance [3] .Also if $A^L = A^U$ is called triangular fuzzy number and denote by

$$A=\left(A^L, \ \alpha, \ \beta\right).$$

Let $a = \left(a^{L}, \ \alpha, \ \beta \right)$, $b = \left(b^{L}, \ \gamma, \ \vartheta \right)$ both be triangular fuzzy numbers .Some of the result of applying fuzzy arithemetic of the fuzzy numbers a, b is same as follows :

Addition:

$$a + b = \left(a^{L} + b^{L}, \alpha + \gamma, \beta + \vartheta \right) . \quad (2)$$

Scalar multiplication:

$$\chi > 0, \chi \in R : \chi a = \left(\chi a^{L}, \chi\alpha, \chi\beta \right), \quad (3)$$

$$\chi < 0, \chi \in R : \chi a = \left(\chi a^{L}, -\chi\beta, -\chi\alpha \right).$$

Subtraction:

$$a - b = \left(a^{L} - b^{L}, \alpha + \vartheta, \beta + \gamma \right) \quad (4)$$

Support function of fuzzy number A is defining same as follows:

Supp $[A] = \{\chi \mid \mu_A(\chi) > 0\}$

Where that $\{\chi \mid \mu_A(\chi) > 0\}$ is closer of set $\{\chi \mid \mu_A(\chi) > 0\}$

Experimental

Fabric wrinkle tester

To investigate the relation of fabric torsional strain properties with woven fabric wrinkle behavior, a new test method different from that of AATCC method is developed.A photograph of the wrinkle tester is shown in Figure 1. Also the test procedure is shown in Figure 2. The related software is based on the labview 6.

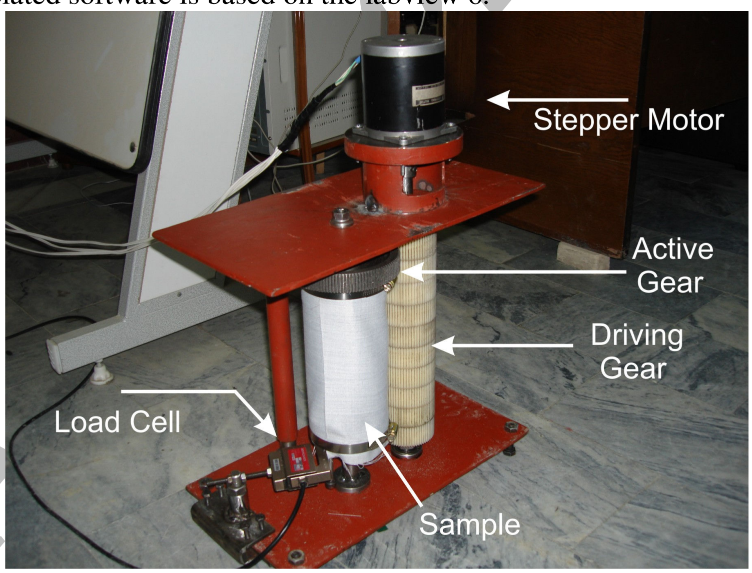

Fig1. A typical picture of fabric wrinkle tester.

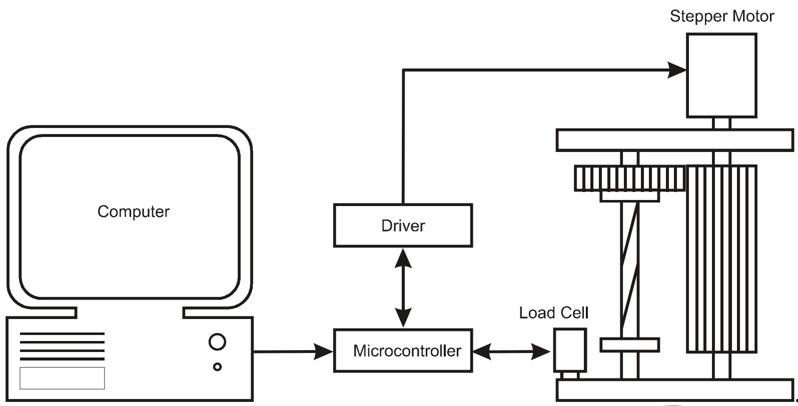

Fig2.shows the test procedure.

So the spiral screw shafts specification is shown table 1.

Table1.Spiral screw shafts specification

Shaft Specification \ Number Of shafts	1	2
Torsional effective Length	110	110
Rotation Throughout the effective length	3/4	1
External diameter(mm)	22	22
Pitch(mm)	146.6	110
Angle(degree)	25.24	32.14

Presentation of different parts of the wrinkle tester

1. Stepper motor (20kg.cm)
2. Loadcell
3. Screw shaft
4. Microcontroller board (the generation of 8051)
5. Personal computer.

Experimental procedure

In this research, 7 different woven twill worsted fabrics as listed in table 2 were used. All fabrics were under the mentioned torsional strains 9 times in warp direction and 9 times in weft direction according to AATCC 128 standard and 20 minutes under loads , the dimensional changing of fabrics was measured in two directions (warp & weft) (Δs) and by use color scanner reduction average of dimensional changes in two directions as dimensional changing from (Δs) in 20 minutes , 1 hour and 24 hours intervals was investigated. The fabric properties are shown in table 2.

Table2. Fabric Properties

Fabric \ parameter	Fibers contentl %	Yarn count (Nm) (weft & warp)	Thickness(mm)	Sample Weight (gr) (150mm*280mm)
A	45p,55w	40/2	0.561	14.17
B	45p,55w	40/2	0.55	14.49
C	70p,30w	40/2	0.54	14.82
D	100%p	40/2	0.56	15.23
E	80p,20w	40/2	0.61	15.11
F	93p,7w	40/2	0.52	14.98
G	90p,10w	40/2	0.59	15.19

Notes: W=Wool, P=Polyester

The experimental results of fabric wrinkling test are shown in table 3.

Table3.Basic Parameters of the wrinkle tester result.

Fabric \ parameter	Max Force (gr) In Warp Direct (shaft1)	Max Force (gr) In Weft Direct (shaft1)	Max Force (gr) In Warp Direct (shaft2)	Max Force (gr) In Weft Direct (shaft2)
A	228	227	1019	975
B	286	167	538	431
C	104	83	1019	980
D	59	40	276	109
E	260	38	1149	264
F	126	96	509	159
G	234	98	1143	509

Results and discussion

Classification and Pattern Recognition

The fuzzy system employed in this paper is such as follows:

Rule $R_j : if \chi_1 \in$ supp $[A_j] \cap$supp$[A_{j+1}]$ then $y = Z_j$,j=0,1,2….,n where supp$[A_j]$ is support function of fuzzy number $[A_j]$ and Z_j is a fuzzy number.

Suppose that every linguistic variable in recovery can have eight linguistic terms: $\{$ very small wrinkle , small wrinkle , little wrinkle , middle wrinkle , wrinkle , big wrinkle , very big wrinkle , high wrinkle $\}$.and their membership function are of triangular from characterized by three parameters (center , left width , right width) of course, the membership functions representing the linguistic terms. $\{vsw, sw, lw, mw, dw, bw, vbw, hw\}$. can vary form input variable to output variable, e.g. the linguistic term " Negative Big" can have maximum N different representation. The fuzzy system's partitioning, is shown in fig3.

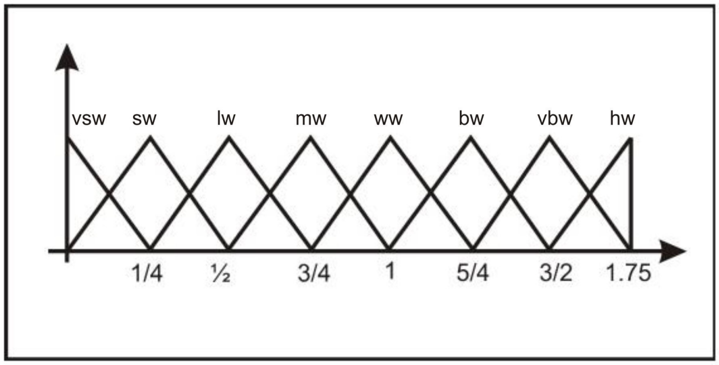

Fig 3.fuzzy system's partitioning

Initial linguistic for the output variable we illustrate the above tuning process by a simple example. Consider fuzzy rule of from above with on input and one output variable

R_1 :if χ is in supp[sw] and in supp[lw] and Then $wrinkle\ (\chi)=\mu_{sw}(\chi)sw+\mu_{lw}(\chi)lw$ (5)

Which by noting addition and scalar multiplication of fuzzy number (3,4)

Wrinkle(X) is a fuzzy number consequently equation is a uncertainly equation is a uncertainly equation for wrinkle recovery.Equation5.is a uncertainly equation for wrinkle recovery. The results fuzzy wrinkle recovery with various torsional strain and time depending are shown table 4 to 8.

Table 4 . The degree of wrinkle Recovery fuzzy after, 20 minutes with shaft1.

R / Class	S_1/S_2	Fuzzy Wrinkle Recovery
A	1.183	(0.933 , 1.183 , 1.433)
B	1.192	(0.942 , 1.192 , 1.44)
C	1.08	(0.83 , 1.08 , 1.33)
D	1.698	(1.438 , 1.698 , 1.736)
E	1.011	(0.761 , 1.011 , 1.267)
F	0.670	(0.42 , 0.67 , 0.92)
G	0.250	(0.125 , 0.25 , 0.375)

Table 5 . The degree of wrinkle Recovery fuzzy after , 60 minutes with shaft1.

R / Class	S_1/S_2	Fuzzy Wrinkle Recovery
A	0.842	(0.592 , 0.842 , 1.092)
B	0.507	(0.257 , 0.507 , 0.757)
C	0.673	(0.423 , 0.673 , 0.923)
D	1.011	(0.761 , 1.011 , 1.261)
E	0.337	(0.087 , 0.337 , 0.587)
F	0.238	(0.0 , 0.238 , 0.488)
G	0.238	(0.0 , 0.238 , 0.488)

Table 6 . The degree of wrinkle Recovery fuzzy after 24 hours with shaft1.

R / Class	S_1/S_2	Fuzzy Wrinkle Recovery
A	0.671	(0.423 , 0.671 , 0.923)
B	0.337	(0.087 , 0.337 , 0.587)
C	0.337	(0.087 , 0.337 , 0.587)
D	0.505	(0.257 , 0.505 , 0.757)
E	0.168	(0.0 , 0.168 , 0.418)
F	0.080	(0.0 , 0.080 , 0.351)
G	0.080	(0.0 , 0.080 0.351)

Table 7 . The degree of wrinkle Recovery fuzzy after , 20 minutes with shaft2.

R / Class	S_1/S_2	Fuzzy Wrinkle Recovery
A	0.842	(0.592 , 0.842 , 1.092)
B	1.350	(1.1 , 1.35 , 1.6)
C	1.693	(1.433 , 1.693 , 1.736)
D	1.011	(0.761 , 1.011 , 1.261)
E	1.693	(1.433 , 1.693 , 1.736)
F	0.330	(0.08 , 0.33 , 0.58)
G	0.673	(0.423 , 0.673 , 0.923)

Table 8 . the degree of wrinkle Recovery fuzzy after 60 minutes with shaft2.

R / Class	S_1/S_2	Fuzzy Wrinkle Recovery
A	0.671	(0.423 , 0.671 , 0.923)
B	0.842	(0.592 , 0.842 , 1.092)
C	1.011	(0.761 , 1.011 , 1.261)
D	0.671	(0.423 , 0.671 , 0.923)
E	1.011	(0.761 , 1.011 , 1.261)
F	0.168	(0.0 , 0.168 , 0.418)
G	0.505	(0.257 , 0.505 , 0.757)

Table 9 . the degree of wrinkle recovery fuzzy after 24 hours with shaft2.

R / Class	S_1/S_2	Fuzzy Wrinkle Recovery
A	0.671	(0.423 , 0.671 , 0.923)
B	0.842	(0.592 , 0.842 , 1.092)
C	0.671	(0.423 , 0.671 , 0.923)
D	0.671	(0.423 , 0.671 , 0.923)
E	0.707	(0.457 , 0.707 , 0.957)
F	0.000	(0.0 , 0.0 , 0.5)
G	0.168	(0.0 , 0.168 , 0.418)

Conclusions

Entering data obtained from 15 fabric different samples which were wrinkled with two torsional strain, it was shown that estimation speed and precision of assumed fuzzy model could be in high and desired level. And result show that the maximum wrinkle forces of the textile are varied in various combinations which tightly depends on viscoelastic properties of fibers so textile wrinkle force is increased by polyester ratio increasing in textile. So the results of this research revealed that fabric samples with higher polyester fiber content exhibited, better wrinkle recovery and less wrinkling.

Reference:

1. Amirbayat, J., and Hearle, J.W.S., *J. Tex. Inst*., **80**, 51 (1989).
2. Zadeh, L.A., *Inf Control*, **8,** 388 (1965**).**
3. Roubens, M., *Dordrecht*, 321 (1991).
4. AATCC Test Methods 124, *AATCC Technical Manual*, **75**, 213 (2000).
5. AATCC Test Methods 128, *AATCC Technical Manual*, **75**, 213 (2000**).**
6. Fazekas, Z., Renyi, I. and Szalai, L., *J. Tex. Inst*., **92**(1), 387 (2001).
7. Mori, T., Komiyama, J., *Tex Res. J.*, **75**(5), 417 (2000).
8. Na, Y.J., and Pourdeyhimi, B., *J. Tex. Inst*., **65**(3), 49 (1995**).**
9. Xu, B., and Reed, J., *J. Tex. Inst*., **86** (1), 129 (1995)
10. Park, C.K., Kan, T., *Tex. Res. J.*, **67**(7), 494 (1997)
11. Mori, T., Endou, Y., *J. Tex. Inst*., **90**(1), 100 (1999)
12. Amirbayat, J., and Alagha, M.J., *J. Tex. Inst*., **87**, 349 (1996)