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Wrinkle Force and Wrinkle Recovery of Worsted Fabrics: A Novel Approach

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Abstract

In current work some structures effect of woven parameters on wrinkle force woven fabrics was investigated. Different textile fabrics including of 5 woven fabric samples with different wool and polyester fiber compositions, fabric designs, yarn count, warp and weft density and woven thickness were prepared and then wrinkle force was continuously measured along two warp and weft directions while constant torsional strain (32 degrees) imposed on the specimen.

For obtaining of wrinkle force, Automatic Wrinkle Force Tester and Wrinkle Recovery Tester AATCC128 made form Shirly corporation for evaluation of wrinkle recovery were used. Also for statistical analysis and modeling consideration SPSS Ver.11 and Curve Expert Ver.1.3 software were utilized. The result shown the some textile structure parameters affected on wrinkle behavior and wrinkle force of woven fabrics in other warp and weft direction were different. Furthermore fabrics density has greater effects on wrinkle force in weft and warp direction than other parameters. However appropriate coefficient of variation between actual and predicted value concluded that nonlinear regression about wrinkle parameters of woven fabrics were obtained.

Keywords: wool/polyester combination percentage, yarn count, warp and weft density, woven thickness and woven pattern, wrinkle of woven fabrics, statistical analysis.

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1. Introduction

Torsional and compress ional properties of fabric are important in clothing manufacturing, wear, washing and dry-cleaning processes. When a fabric undergoes the influence of external compression and torsional forces, the fabric will bend and buckle in different directions and hence wrinkle will be created into the fabric.

Hezavehi et al, presented a new approach for wrinkle recovery evaluation of worsted fabrics using fuzzy systems. 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 [1].

Hezavehi et al, investigated new test method to characterize torsional behavior of woven fabrics which 6 different worsted wool blended fabric samples were used and then the torsional force of these fabrics were continuously measured along two warp and weft directions using 3 different spiral shafts with 25, 32, and 60 torsional angle degrees, respectively. In their research, results indicated that with a spiral shaft of 60 degrees, the torsional forces of all fabric samples were almost similar particularly for fabric samples tested along weft direction [2].

Shaikhzadeh et al, considered of wrinkle parameters such as wrinkle force, hysteresise parameter of energy and worsted fabrics resilience. They obtained that with increase of torsional strains, the torsional force is increased. Also in worsted fabric samples with higher wool fiber content exhibited lower torsional force. The results of this research also suggested that the torsional force of worsted fabrics in warp direction is significantly higher than in weft direction [3].

Shinohara et al.,[4,5] analyzed the garment wrinkling by deforming a fabric cylinder in axial compression. They found that the buckling pattern generated in knitted fabrics is different from that in woven fabrics. In their further theoretical work, they proposed a mathematical model to describe the buckling deformation of a woven fabric cylinder in axial compression.

Hezavehi et al, examined a new electro-mechanical technique for measurement of stress relaxation of polyester blended fabric with constant torsional strain. They obtained stress relaxation percentage in fabric in weft alignment is more than warp alignment and the fabrics which tolerate more torsional force, posses less stress relaxation percentages. In this way with increasing polyester percentage in fabric the scale of stress relaxation percentage decreases [6].

In standard technique of wrinkle recovery tester, the fabric is shell cylindrical formed so compressed and rotated under constants of axial load (3.5 Kg) and rotational angle [7]. However, in this method, it is not possible to measure the torsional force of woven fabrics under the combined influences of compression and torsional strains.

In the literature we didn’t find any same researches in this filed. The aim of this work was an investigation of wrinkle force textile structures in a cylindrical form using statistical models. For this reason effect of woven fabrics structural parameters on their wrinkle force with utilize of statistical models were considered.

2.Experimental

1,2. Material

In this research, 5 different woven fabrics were used. The general fabrics specifications are shown in Table 1.

Table1. General fabrics specifications

Samples	Thickness (mm)	Warp Density(cm^{-1})	Weft Density(cm^{-1})	Combination percentage (%)	Yarn count(Nm)	Fabric Design
A	0.59	28	19	P55,W45	30	T $\frac{2}{1}$
B	0.68	30	20	P80,W20	20	T $\frac{2}{1}$
C	0.64	23	19	P80,W20	20	T $\frac{2}{1}$
D	0.67	30	23	P55,W45	20	T $\frac{2}{2}$
E	0.61	28	22	P68,W32	24	T $\frac{2}{2}$

* P: polyester, W: wool

2, 2.Measurement of wrinkle force and winkle recovery

For obtaining of wrinkle force amount, Automatic Wrinkle Force Tester was used. In this tester, the rectangular fabric specimen (with dimensions of 290 mm ×160 mm) formed into a cylinder shape and then mounted between two circular rings in 90 mm diameter [2,3].

Also for evaluation of wrinkle recovery was used of Wrinkle Recovery Tester AATCC128 made form Shirly corporation [7]. The average of means obtaining each method is presented in Table 2. Therefore a photograph of the wrinkle force tester and wrinkle recovery tester of Shirly corporation are shown in Figure 1 and 2 respectivley. A Lab view software Ver.6 (National Instrument Co.) is used in order to run, control the apparatus and register and monitor the data. Typical diagram that obtained for sample A with wrinkle force in weft direction from this software is shown in Figure 3.

Table2. The average of means obtaining each method

Samples	Wrinkle Force in weft direction(N)	Wrinkle Force in warp direction(N)	Wrinkle Recovery in weft direction	Wrinkle Recovery in warp direction
A	5.096 *(0.18)	5.635 (0.21)	3.4 (0.54)	2.4 (0.54)
B	9.0454 (0.11)	13.622 (0.06)	3.8 (0.44)	3.2 (0.44)
C	7.497 (0.10)	15.1116 (0.08)	1.2 (0.44)	1.2 (0.44)
D	10.7114 (0.08)	12.1618 (0.44)	2.8 (0.44)	2.2 (0.44)
E	10.0352 (0.15)	12.3382 (0.12)	2.2 (0.44)	2.4 (0.54)

*Note: The data in brackets are SD values

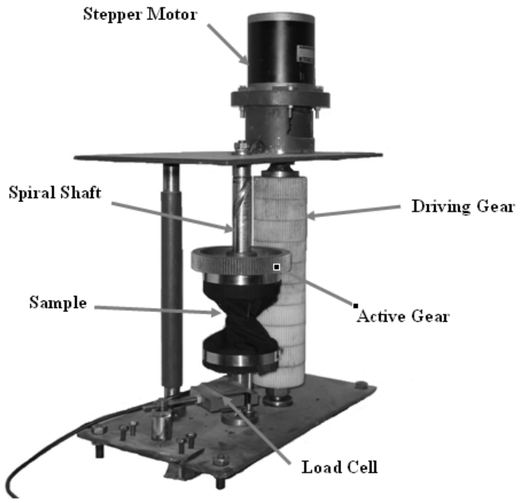


Figure1. A photograph of the wrinkle force tester [1, 3]

Figure2. Wrinkle recovery tester of Shirly corporation

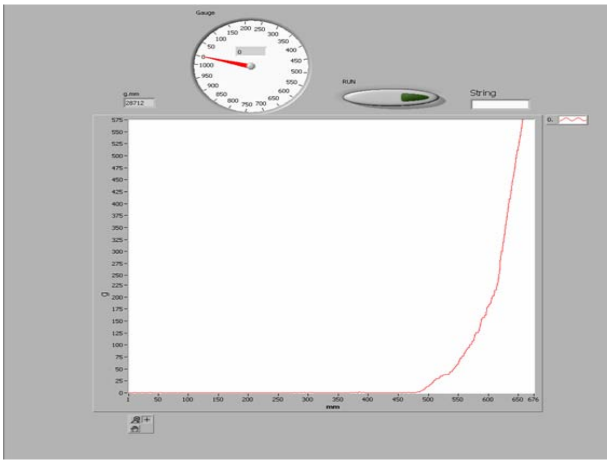


Figure3. A Typical diagram for sample A with wrinkle force in weft direction (Lab view software Ver. 6 measurement)

3,2. Statistical methods

Nowadays using of statistical approach has promotive condition and in most engineering research is erected on analysis of variances (ANOVA), Duncan tests nonlinear regressions methods [8, 9,10].

For this reason the experimental results of fabric wrinkle force and wrinkle recovery values were statistically analyzed using analysis of variance (ANOVA), Duncan tests and nonlinear regression. Also for statistical analysis and modeling consideration SPSS Ver.11 and Curve Expert Ver.1.3 software were utilized.

4. Results and discussions

1, 4. Statistical analysis

Effect of woven fabrics structural parameters in two directions of warp and weft on wrinkle force and wrinkle recovery with used of analyzes of variance (ANOVA) and Duncan methods are shown in Table 3-8.

Table3. Woven fabrics structural parameters effect on wrinkle force and wrinkle recovery with used of analyze of variance (ANOVA) method.

Force	Yarn count		Combination Percentage		Warp density		Weft density		Fabric design		Fabric Thickness	
	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Weft direction	16.815	0.000	2.047	0.153	5.276	0.013	40.896	0.000	33.542	0.000	2.323	0.344
Warp direction	0.163	0.851	14.733	0.000	13.515	0.000	1.211	0.330	0.333	0.569	4.790	0.187

Table4. Duncan Homogeneous Subsets test of yarn count on wrinkle force of woven fabrics in weft direction.

Duncan [a]

yarn count	Replication	Subset for alpha = .05	
		1	2
30	15	7.2128	
24	5		10.0352
20	5		10.7114
Sig.		1.000	.378

Means for groups in homogeneous subsets are displayed.

A Uses Harmonic Mean Sample Size = 6.429.

B The group sizes are unequal. The harmonic mean Of the group sizes is used.

Type I error levels are not guaranteed

Table5. Duncan Homogeneous Subsets test of combination percentage on wrinkle force of woven fabrics in warp direction.

Duncan [a]

combination percentage	Replication	Subset for alpha = .05	
		1	2
P55,W45	10	8.8984	
P68,W32	5		12.3382
P80,W20	10		14.3668
Sig.		1.000	.097

Means for groups in homogeneous subsets are displayed.

a Uses Harmonic Mean Sample Size = 7.500.

b The group sizes are unequal.

The harmonic mean of the group sizes is used.

Type I error levels are not guaranteed.

Table6. Duncan Homogeneous Subsets test of warp density on wrinkle force of woven fabrics in weft direction.

Duncan [a]

warp density	Replication	Subset for alpha = .05	
		1	2
22	5	7.4970	
28	10	7.5656	
30	10		9.8784
Sig.		.941	1.000

Means for groups in homogeneous subsets are displayed.

A Uses Harmonic Mean Sample Size = 7.500.

B The group sizes are unequal.

The harmonic mean of the group sizes is used.

Type I error levels are not guaranteed.

Table7. Duncan Homogeneous Subsets test of warp density on wrinkle force of woven fabrics in weft direction.

Duncan [a]

warp density	Replication	Subset for alpha = .05	
		1	2
28	10	8.9866	
30	10		12.8919
22	5		15.1116
Sig.		1.000	.078

Means for groups in homogeneous subsets are displayed.

A Uses Harmonic Mean Sample Size = 7.500.

B The group sizes are unequal.

The harmonic mean of the group sizes is used.

Type I error levels are not guaranteed

Table8. Duncan Homogeneous Subsets test of weft density on wrinkle force of woven fabrics in warp direction.

Duncan [a]

weft density	Replication	Subset for alpha = .05		
		1	2	3
19	10	6.2965		
20	5		9.0454	
22	5		10.0352	10.0352
23	5			10.7114
Sig.		1.000	.059	.187

Means for groups in homogeneous subsets are displayed.

A Uses Harmonic Mean Sample Size = 5.714.

B The group sizes are unequal. The harmonic mean of the group sizes is used.

Type I error levels are not guaranteed.

As shown in Tables 3, yarn count, weft and warp density and fabric design have significantly influenced on wrinkle force weft direction and also combination percentage and weft density have significantly affected on warp direction. Also in this table it’s revealed that wrinkle force did not influence on wrinkle recovery amounts.

Regarding to recent table because variation domain of fabrics thickness is limited and so this thickness can be resembled of thin layer thus thickness effect on wrinkle force was insignificant.

Whereas fabrics which have greater warp density, this parameter effect can be revealed on wrinkle force according to orthotropic feature of woven fabrics. As with increase of warp density so ascending of polyester percentage in yarn samples the wrinkle force in weft direction was increased.

In the other hand, fabric design in weft direction has influenced on wrinkle force. Because rotating direction of instrument is clockwise and also fabrics pattern is Z type. Also fabric design has obviously affected on wrinkle force in the weft direction.

As it can be seen in the Table 3 there is no significant relationship between wrinkle force and wrinkle recovery of samples. Because instrument which is made, performed these tests with C.R.E but standard wrinkle instrument worked with C.R.L methods. Therefore between these two qualitative and quantitative parameters were not obtained reasonable relationship.

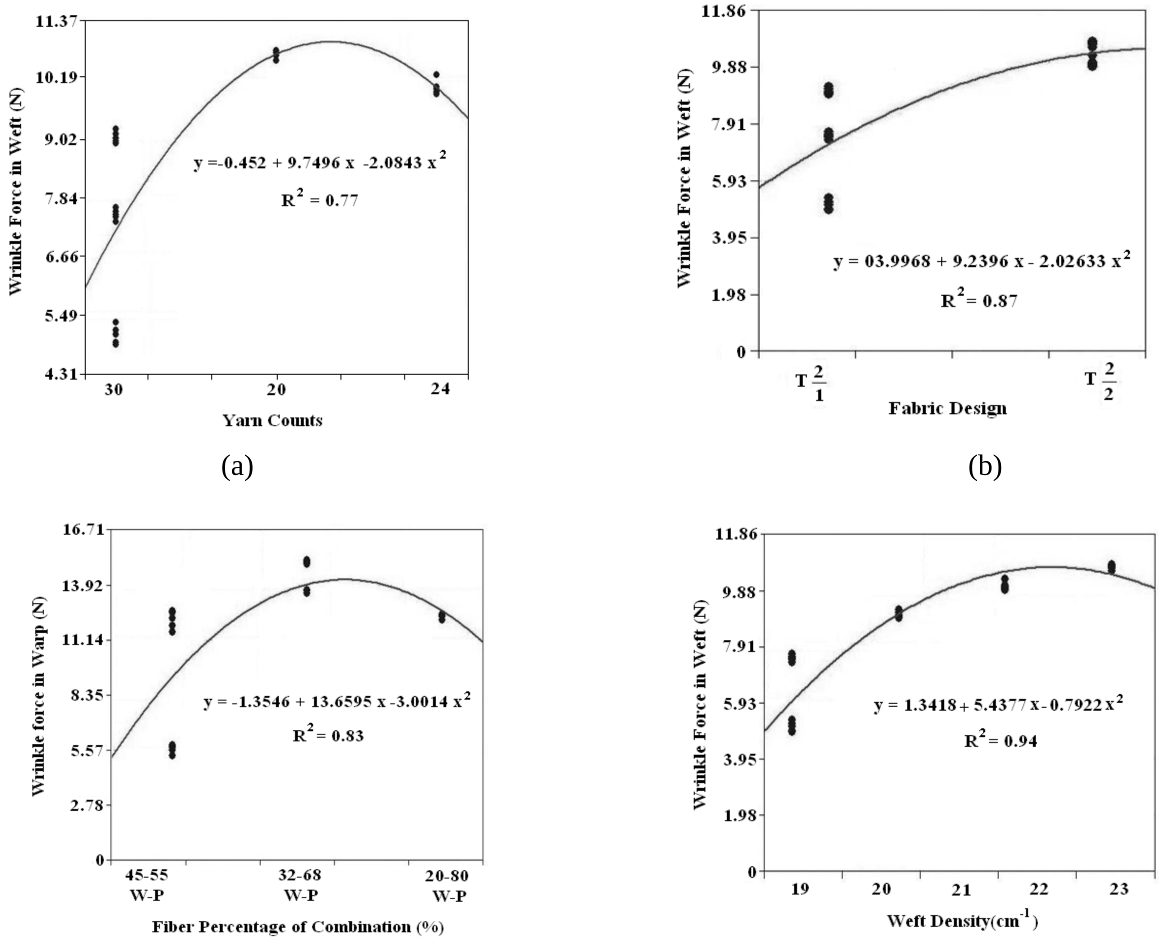
2,4. Regression models

According to results which were obtained significant parameters that are affected on wrinkle force, finally they were used for modeling with regression methods. These parameters are listed in Table 9.

Table9. Parameters significant which were obtained from analysis of variance (ANOVA)

Structural parameters	Type of direction	
	weft	warp
Yarn count	+	-
Fabric design	+	-
Weft density	+	-
Warp density	+	+
Combination percentage	-	+

For obtaining of appropriate regression fitted on these parameters Curve Expert ver 1.3 software was used. Meanwhile results which were observed of regression analysis are shown in Figures 4 and 6.



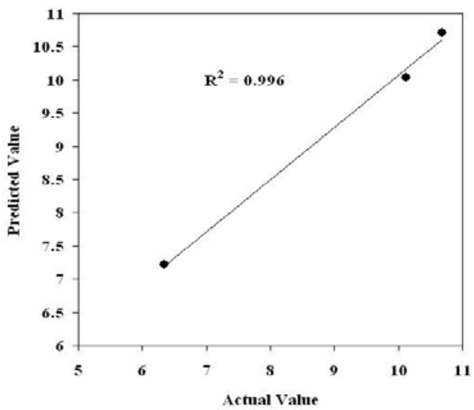
(a) (b)

(c) (d)

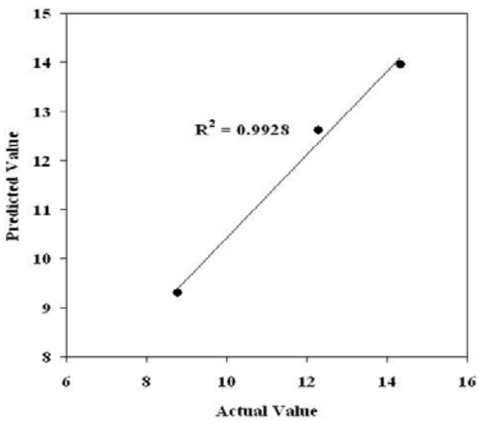
Figure4. Quadratic regression of effective parameters, a) yarn count effect on wrinkle force in weft direction, b) fabric design effect on wrinkle force in weft direction, c) fiber percentage of combination on wrinkle force in warp direction, d) weft density effect on wrinkle force in weft direction

As is inferred from Figures 4 and 6, effective parameters on structural feature of woven fabrics are regressed and relevant data estimated. Moreover it can be seen in Figures 4-a, 4-d that higher R-square is 94% for weft density effects on wrinkle force in weft direction and lower R-square is 77% for yarn counts effect on in the same parameter. It can be concluded that effect of weft density with relative in orthotropic behavior of woven fabrics is conformed to results. It means that wrinkling and bending of samples are affected with weft density of fabrics and this observation can be testified. Also data have been estimated with regression is firmly fitted with quadratic equation in Figure 4-d. From this figure, it is observed that with increasing of weft density, wrinkle force in weft direction is also increased.

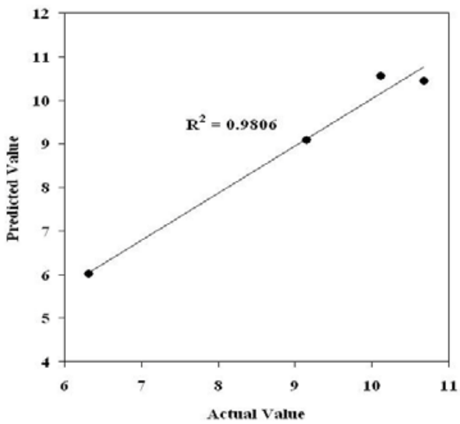
In the other hand for justification of predicted data from regression equations correlation coefficient between experimental and estimated values was considered. These results are presented in Figures 5 and 7.



(a)



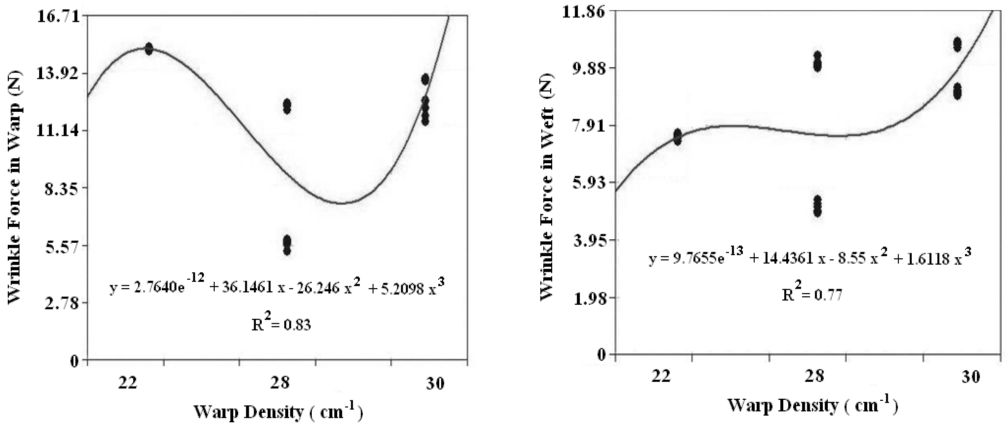
(b)



(c)

Figure5. Correlation between experimental and predicted values, a) predicted data for yarn count values, b) predicted data for fiber percentage of combination, c) predicted data for weft density

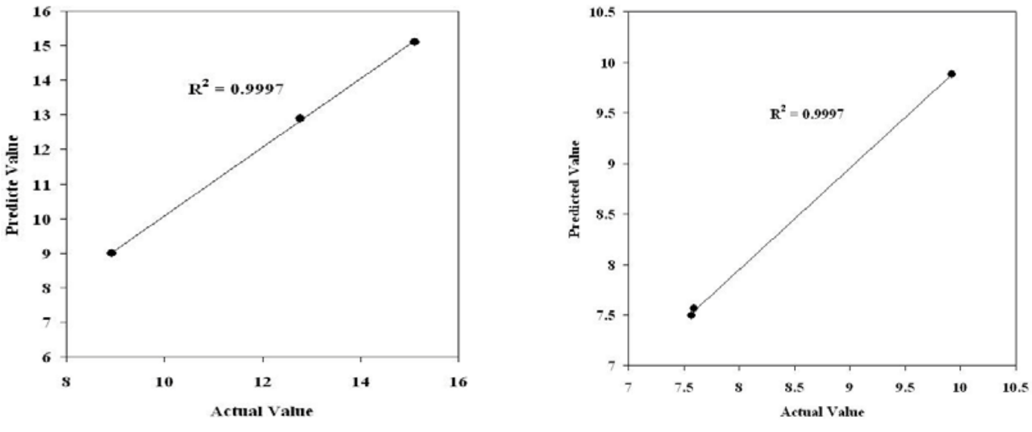
According to Figure 5, quadratic regression results and experimental data with both relationships are confirmed with correlation of coefficient analysis. It can be observed that there is tightly positive correlation between actual and estimated data.



(a) (b)

Figure6. Cubic regression of effective parameters, a) warp density on wrinkle force in warp direction, b) warp density on wrinkle force in weft direction

In Figure 6 that is continued of regression processing including of cubic regression which is determined for evaluation of warp density effect on wrinkle force on warp and weft direction are respectively showed. As can be seen in this figure the effect of warp density are alike of weft density effects has a closely influenced on wrinkle force but in this case affected on two directions. Orthotropic behavior of woven fabrics and higher R-square like 85% in Figure 6-a are also conformed recent observation especially when warp density has influenced on wrinkle force in warp direction.



(a) (b)

Figure7. Correlation between experimental and predicted values, a) predicted data for warp density values on wrinkle force in warp direction, b) predicted data for warp density values on wrinkle force in weft direction

However Figure 7-a & b are shown same correlation indexes but it can establish regression capability for evaluating of data parameters.

5. Conclusion

Nowadays using of statistical modeling and investigation has an abundant application in engineering subjects especially in textile researches.

The aim of this paper is evaluation of some structures effect of woven parameters on wrinkle force and wrinkle recovery woven fabrics. Nonlinear regression and statistical analysis were developed on data parameters in this consideration. Verification was done through comparison with some experimental results in woven fabrics. Good agreement was observed between the wrinkle forces in different direction with effective parameters such as yarn count, fabric design, weft density, warp density and fiber combination percentage. Results shown that fabrics density has greater effects on wrinkle force and wrinkle recovery in weft and warp direction than other parameters, Regression method which is utilized and conformed these result properly. In the other hand orthotropic behavior of fabrics has completely testified with these observations.

6. References

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