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AUTO PLOT STIFFNESS TESTER-PERFORMANCE EVALUATION WITH SHIRLEY STIFFNESS TESTER

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ABSTRACT

A new Auto-Plotter stiffness tester is developed to reduce human interference in the bending measurement. This paper highlights the investigation made on the tester in order to confirm the reliability of its measurement. For that, 40 controlled samples were developed and 29 commercials were selected and tested for bending length, bending modulus. These results are compared with the Shirley stiffness tester results of the sample.

The statistical tools such as ANOVA, paired mean test, Wilcoxon signed rank test and multiple correlation regression are used to know the significance differences among the samples as well as between Auto-Plot tester and Shirley. The results of Auto-Plot tester are comparable with Shirley Tester; Auto Plot Stiffness Tester has an advantage of examining the intermediary behavior of samples before reaching 41.5 degrees. This Auto-Plot tester has provision for storing the data's and further it may be electronically transmitted to other sources.

KEYWORDS: Auto-Plotter, Stiffness Tester, Human Interference & Bending Measurement

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Original Article

INTRODUCTION

Experimental

Eight controlled samples are generated based on the following titles

- Two different counts namely 40's and 2/20's are used
- Keeping both warp and weft count constant, changing the constructions
- Keeping both wrap and weft, as well as construction constant changing EPI and PPI

Table 1

Sample Nos	Wrap Count	Weft Count	EPI	PPI	Weave
1	40's	40's	84	70	Plain
2	40's	40's	84	70	Matt
3	40's	40's	58	52	Plain
4	40's	40's	58	52	Matt
5	2/20's	2/20's	58	40	Plain
6	2/20's	2/20's	58	40	Matt
7	2/20's	2/20's	40	30	Plain
8	2/20's	2/20's	40	30	Matt

Scouring

Further, the Eight Samples are scoured to remove actual vegetable matters with the following recipe

Liquor Ratio: 1:20

Wetting Agent: 0.751

Caustic Soda: 2.1

Temp: - 100̊C

Time: - 4 to 6 hours

The scouring bath is set by taking required quantities of caustic soda, Soda ash, and wetting agent, keeping M:L ratio of 1:20 the wetted material is entered into scouring bath and Temperature is immediately raised to boil and in boiling temperature, the material is worked for 4-6 hours. The samples were steeped overnight in the same liquor and then washed thoroughly with water on the next day.

Bleaching

Retaining some portion of the scoured sample, remaining samples are subjected to the bleaching to remove natural coloring matter with the following recipe

Liquor Ratio: 1:20

Wetting Agent: 0.751

Hydrogen peroxide one volume (half bleach)

Sodium silicate 2 gpl

Initially, the samples are soaked in water containing a wetting agent, then the bleaching bath is set at the room temperature by taking one volume of Hydrogen peroxide and 2 gpl of Sodium silicate (stabilizer) for obtaining half bleach. Buffer the bleach solution with caustic or soda ash at Ph 11.5 now the pre-wetted samples are entered into the bleaching bath and worked for few minutes then the temperature of the bath is raised to 80 to 90 degree centigrade and the material is worked 30 minutes and temperature is raised to 95 degrees centigrade at this temperature the samples were treated for 60 minutes

Finally, after the treatment, the sample is taken out rinsed well in clean water and washed thoroughly

Dyeing

Previously scoured and bleached samples are further dyed with reactive dyes (prawn magenta MB) using the cold method with two shade percentage of 0.5 and 3% with the following recipe.

Reactive Dye: - 0.5% to 3%

Soda Ash: - 5 gpl to15 gpl

Common Salt: - 15 gpl to 80 gpl

The Dye stuff is pasted in cold water and diluted with water at 30 to 50 degree and should not be boiled under any

circumstance. Then the diluted dyestuff is added to the required quantity of water, previously wetted samples are entered in this dye bath, worked for 10 minutes. The requisite quantity of common salt is added to this dye bath in installments over the period of 40 minutes. During dyeing, the samples were turned several times and required quantity of soda ash is added to this dye bath which assists in dye fixation. Further, the samples were worked for one hour then taken out washed with clean water.

After dyeing the samples were soaped at the boil with 1.5 gm per liter by synthetic detergent for 30 minutes and finally washed.

Totally 40 samples were prepared in this fashion (8 each of grey, scoured bleached, 0.5% dyed, 3% dyed) to test on the newly developed Auto Plot Stiffness Tester.

All these 40 controlled samples and 29 commercial samples are tested on Auto Plot Stiffness Tester and Shirley Tester. In Auto Plot Stiffness Tester, controlled samples are tested in 1, 2, 5 and 10 mm movement, as the sensor is fixed at 7 mm distance from the edge of sample measurement bed, for 1 and 2 mm movement, the samples have to be moved 10 mm initially, then has to commence the testing. This 10 mm should be added to the Auto Plot Stiffness Testers output readings.

29 commercial samples are tested with 1 and 2 mm movement on Auto Plot Stiffness Tester. This instrument takes approximately 9 Sec to detect bending angle and same is displayed over TFT Screen as a table and a graph. This data is also stored in database.

Following 29 Commercial samples are selected and following table gives constructional details of them

Table 2

Sl. No	Samples	EPI	PPI	Wrap-Count	Weft-Count	Wrap-Crimp	Weft-Crimp	Weave	GSM	Thickness
1	Poly/cot Blended panting	38	36	6	6	2.4	3.2	PLAIN	262	0.47mm
2	Poly/viscose panting	104	108	18	30	3.5	5.2	MATT	176	0.25mm
3	Viscose	54	60	26	28	1.2	1.2	PLAIN	106	0.27mm
4	Poly blended	84	88	18	34	4	4.8	TWILL	224	0.4mm
5	Cotton shirting	66	48	31	18	1.5	5	PLAIN	133	0.27mm
6	Filament shirting	70	64	39	38	4	4	PLAIN	83	0.15mm
7	Poly cotton printed shirting	70	70	40	40	3	4	PLAIN	121	0.22mm
8	100% poly shirting	74	64	70	39	3.3	2	PLAIN	101	0.18mm
9	Cotton biended	58	60	28	26	2	3.5	PLAIN	134	0.29mm
10	Poly viscose shirting	80	64	45	37	7	5	PLAIN	106	0.17mm
11	Polycotton shirting	120	78	38	30	4.6	2	PLAIN	128	0.27mm
12	Polycotton shirting	88	64	42	38	3	3.3	PLAIN	118	0.24mm
13	Cotton shirting	92	72	22	40	2.5	2	PLAIN	125	0.22mm
14	Jeans	64	52	13	10	5.5	18	3/1TWILL	341	0.64mm
15	Khaki	68	52	12	11	1.5	5	PLAIN	218	0.34mm
16	Drill	88	46	8	14	1.5	2.5	3/1 TWILL	291	0.48mm

Table 2: Contd.,										
17	Silk	104	116	134	24	3	0.5	PLAIN	61	0.2mm
18	Jamkhan	36	18	4	6	1	1	WARP RIB	374	1.15mm
19	Poly shirting	90	76	34	34	3.5	1.5	PLAIN	104	0.18mm
20	Cotton viscose blended	76	68	20	14	7	2	PLAIN	195	0.32mm
21	Cotton wool panting	58	72	12	13	2.5	2	PLAIN	191	0.31mm
22	Poly wool suiting	64	58	10	12	4	2.5	2/1 TWILL	246	0.38mm
23	Poly cotton panting	72	60	13	12	5.5	4.5	2/1 TWILL	221	0.39mm
24	Panting	88	74	13	26	3	2	2/1 TWILL	169	0.27mm
25	100% poly panting	70	74	12	27	2	1.5	PLAIN	174	0.29mm
26	Panting	72	66	30	17	4.6	1	4/1 TWILL	204	0.37mm
27	Poly viscose panting	68	62	16	28	3.3	3	2/1 TWILL	215	0.36mm
28	Panting	58	58	13	12	2	6	2/1 TWILL	199	0.33mm
29	Panting	64	60	12	13	2	5	MATT	238	0.39mm

The results of controlled samples are tested with Wilcoxon signed Rank Test, below table shows the results of the test.

Table 3

Wlcoxon Signed Rank Test Results - indicate p-valu with * if it is Retain Null Hypothsys otherwise indicate numberin red color without *

Sample ID			2mm-5mm	2mm-10mm	5mm-10mm	2mm-Shirley	5mm-Shirley	10mm-Shirley	1mm-2mm	1mm-shrley	1mm-5mm	1mm-10mm
58X40	Plain	Grey	.496*	.892*	.102*	.892*	.223*	.892*	**0.655***	**0.892***	0.221*	0.892*
58X40	Plain	Scoured	0.042	0.043	0.577*	0.102*	0.043	.068*	0.273*	0.892*	0.080*	0.225*
58X40	Plain	Bleached	0.223*	.413*	1.00*	1.000*	.223*	.416*	0.854*	1.00*	0.136*	0.408*
58X40	Plain	1 Dyed	0.357*	.068*	.655*	.269*	.854*	.581*	0.414*	0.144*	0.223*	0.041
58X40	Plain	3 Dyed	.157*	.157*	1.00*	.414*	1.00*	1.00*	0.564*	0.465*	0.276*	0.276*
58X40	Mat t	Grey	0.068*	0.257*	0.564*	0.785*	0.041	.480*	1.00*	0.683*	0.066*	0.257*
58X40	Mat t	Scoured	.680*	.131*	0.025	.786*	.564*	0.041	0.680*	0.854*	1.00*	0.039
58X40	Mat t	Bleached	.141*	.141*	1.00*	1.00*	0.041	0.041	1.00*	0.705*	0.066*	0.066*
58X40	Mat t	1 Dyed	0.043	0.042	0.317*	0.034	.683*	.336*	0.317*	0.042	0.043	0.043
58X40	Mat t	3 Dyed	.336*	.221*	.705*	0.041	.216*	.683*	0.039	0.223*	0.104*	0.223*
40X30	Plain	Grey	.461*	.194*	.317*	.564*	.461*	.059*	1.00*	0.480*	0.683*	0.131*
40X30	Plain	Scoured	0.034	0.034	0.046	.059*	.492*	0.034	0.039	1.00*	0.492*	0.038
40X30	Plain	Bleached	.345*	0.042	0.034	.273*	0.041	0.041	0.786*	0.496*	0.221*	0.041
40X30	Plain	1 Dyed	0.042	.144*	.066*	.686*	0.343*	.078*	0.891*	0.588*	0.080*	0.104*
40X30	Plain	3 Dyed	.892*	.109*	.317*	.416*	.684*	0.038	1.00*	1.00*	0.786*	0.066*
40X30	Mat t	Grey	.221*	.684*	1.00*	.180*	.098*	.680*	1.00*	0.083*	0.408*	0.683*
40X30	Mat t	Scoured	.059*	.059*	1.00*	.713*	0.041	0.041	0.066*	0`046	0.083*	0.083*
40X30	Mat t	Bleached	.157*	0.038	0.046	.059*	.498*	0.039	0.039	0.083*	0.408*	0.034
40X30	Mat t	1 Dyed	.414*	.285*	.197*	.102*	.273*	.683*	0.414*	0.285*	0.285*	0.269*
40X30	Mat t	3 Dyed	.892*	.221*	0.046	1.00*	.102*	0.039	0.893*	0.586*	0.581*	0.141*
84X70	Plain	Grey	1.00*	0.041	0.025	.273*	.892*	.144*	0.705*	0.588*	0.343*	0.042
84X70	Plain	Scoured	0.046	0.046	1.00*	.317*	.180*	.180*	0.713*	0.713*	0.109*	0.109*
84X70	Plain	Bleached	.066*	.059*	.317*	.129*	0.042	0.039	0.713*	0.157*	0.042	0.041
84X70	Plain	1 Dyed	.655*	.317*	.317*	.317*	.705*	1.00*	0.083*	0.059*	0.713*	0.059*
84X70	Plain	3 Dyed	0.034	0.025	0.046	.063*	1.00*	0.041	0.564*	0.059*	0.102*	0.041
84X70	Mat t	Grey	.131*	.336*	0.046	.786*	.223*	.157*	0.257*	0.893*	0.102*	0.223*
84X70	Mat t	Scoured	0.025	0.025	0.025	.083*	.655*	0.038	0.038	0.414*	0.083*	0.038
84X70	Mat t	Bleached	.684*	.157*	.564*	.854*	.683*	0.129	0.68*	1.00*	0.892*	0.039
84X70	Mat t	1 Dyed	0.034	0.034	0.025	.157*	0.034	0.034	0.564*	0.257*	0.066*	0.042
84X70	Mat t	3 Dyed	0.039	0.039	1.00*	.577*	0.038	0.038	0.257*	0.414*	0.041	0.041
58X52	Plain	Grey	.343*	.223*	.480*	.786*	1.00*	.336*	0.317*	0.786*	0.461*	0.279*
58X52	Plain	Scoured	.059*	.059*	1.00*	.891*	.141*	.141*	0.892*	0.581*	0.041	0.041
58X52	Plain	Bleached	.713*	.059*	.083*	.655*	.891*	0.041	0.783*	0.48*	0.655*	0.038
58X52	Plain	1 Dyed	0.025	0.025	0.025	.063*	0.041	0.041	0.157*	0.157*	0.038	0.038
58X52	Plain	3 Dyed	0.038	.077*	.317*	.074*	0.042	.414*	0.046	0.157*	0.041	0.102*
58X52	Mat t	Grey	.680*	0.034	.102*	.450*	1.00*	0.041	0.564*	0.414*	0.786*	0.041
58X52	Mat t	Scoured	1.00*	0.039	0.025	1.00*	1.00*	0.039	0.334*	0.334*	0.066*	0.042
58X52	Mat t	Bleached	.221*	.496*	.705*	.713*	.066*	.786*	0.157*	0.496*	0.680*	0.683*
58X52	Mat t	1 Dyed	.221*	0.038	0.034	.059*	.705*	0.034	0.655*	0.034	0.480*	0.025
58X52	Mat t	3 Dyed	.465*	.109*	.317*	.581*	.078*	0.042	0.317*	0.854*	0.343*	0.041

The instrument developed has been tested at the rate of sample movement of 1, 2, 5 and 10mm. There is very good agreement between 1 mm and Shirley test results and also 2mm and Shirley test results. The lower agreement of 5

mm and 10 mm movement with Shirley test results is understandable as the faster rate of movement of the sample is not allowing for complete relaxation

Bending Modulus in KG/SQ.MT and Single Factor ANOVA

Further ANOVA test is conducted on the bending modulus values of 2 mm movement of Auto Plot Stiffness Tester and Shirley Tester. Below table shows the results of ANOVA.

Table 4

Bending Modulus in Kg/Sq.mt and Single factor ANOVA			
Process condit ɔn	2mm	Shirley	ANOVA p-value
Grey	4.14651419	3.45542849	0.84156703
Scoured	4.44314601	4.56007091	
Bleached	3.12468019	3.23242778	
3 Dyed	3.43776495	3.54986598	

The Bending modulus value computed for Auto plotter and Shirley tester is not significantly different, again confirming the validity of Auto plotter.

TEST RESULTS OF COMMERCIAL SAMPLES

29 woven commercial samples were tested for their bending behavior on Auto-plotter at 1mm and 2mm and Shirley tester. The Table shows the details of samples and bending length at 41.5 deg.

Table 5

Commercial Samples Result

Sl.Nos	Samples	EPI	PPI	Wrap-Count	Weft-Count	Wrap-Crimp	Weft-Crimp	Weave	GSM	Thickness	1 mm-Avg	2 mm-Avg	Shriely-Avg
1	poly/cot Blended panting	38	36	6	6	2.4	3.2	PLAIN	262	0.47mm	18.75	19	19
2	poly/viscose panting	104	108	18	30	3.5	5.2	MATT	176	0.25mm	15.8	15.2	15
3	viscose	54	60	26	28	1.2	1.2	PLAIN	106	0.27mm	24.9	24.4	24
4	poly blended	84	88	18	34	4	4.8	TWILL	224	0.4mm	18.8	19	19
5	cotton shirting	66	48	31	18	1.5	5	PLAIN	133	0.27mm	23.7	23.4	23
6	filament shirting	70	64	39	38	4	4	PLAIN	83	0.15mm	29.6	29.4	30
7	polycotton printed shirting	70	70	40	40	3	4	PLAIN	121	0.22mm	10.7	10.6	10
8	100% poly shirting	74	64	70	39	3.3	2	PLAIN	101	0.18mm	14.9	14.6	15
9	cotton biended	58	60	28	26	2	3.5	PLAIN	134	0.29mm	14.3	14	14
10	polyviscoe shirting	80	64	45	37	7	5	PLAIN	106	0.17mm	17.2	17	17
11	polycottonshirting	120	78	38	30	4.6	2	PLAIN	128	0.27mm	17.8	17.5	17
12	polycottonshirting	88	64	42	38	3	3.3	PLAIN	118	0.24mm	11	11	12
13	cottonshirting	92	72	22	40	2.5	2	PLAIN	125	0.22mm	17.3	17.3	18
14	Jeans	64	52	13	10	5.5	18	3/1TWILL	341	0.64mm	30.5	30.6	30
15	Khaki	68	52	12	11	1.5	5	PLAIN	218	0.34mm	17.3	17	18
16	Drill	88	46	8	14	1.5	2.5	3/1TWILL	291	0.48mm	18	17.8	18
17	Silk	104	116	134	24	3	0.5	PLAIN	61	0.2mm	13.6	13.4	14
18	Jamkhan	36	18	4	6	1	1	WARP RIB	374	1.15mm	22.4	22	22
19	poly shirting	90	76	34	34	3.5	1.5	PLAIN	104	0.18mm	11.8	11.8	12
20	cottonviscoe blended	76	68	20	14	7	2	PLAIN	195	0.32mm	16.4	16.6	17
21	cotton woo pantingl	58	72	12	13	2.5	2	PLAIN	191	0.31mm	17.2	17.2	18
22	poly wool suiting	64	58	10	12	4	2.5	2/1 TWILL	246	0.38mm	17	16.6	17
23	poly cotton panting	72	60	13	12	5.5	4.5	2/1 TWILL	221	0.39mm	14.9	14.6	15
24	panting	88	74	13	26	3	2	2/1 TWILL	169	0.27mm	19.4	19.6	20
25	100% poly panting	70	74	12	27	2	1.5	PLAIN	174	0.29mm	17.1	17	17
26	panting	72	66	30	17	4.6	1	4/1 TWILL	204	0.37mm	12.8	12.6	13
27	poly viscoe panting	68	62	16	28	3.3	3	2/1 TWILL	215	0.36mm	13.7	13.6	14
28	panting	58	58	13	12	2	6	2/1 twill	199	0.33mm	15.6	15.8	16
29	panting	64	60	12	13	2	5	MATT	238	0.39mm	16.3	16	17

The multiple regression coefficients are calculated for the hanging length registered at 41.5 degree son Auto-Plot tester at 1and 2mm fabric movement and Shirley tester against yarn count, thread density, crimp and thickness.

Table 6

Results of Multiple regression	
Test Condition	**R**
Auto Plotter1 mm	0.5618
Auto Plotter2 mm	0.5676
Shirley tester	0.5522

The Regression coefficient more or less same. The table below shows the bending modulus of commercial samples at 1, 2mm and Shirley tester.

Table 7

Sl. No	Sample Name	GSM	Thickness	Bending Modulus			ANOVA P-value
				1 mm	2 mm	Shirley Tester	
1	A	262	0.47	26.35463	0.316256	26.70602	
2	B	176	0.25	99.1283	0.148692	94.10914	
3	C	106	0.27	74.68989	0.033196	71.99026	
4	D	224	0.4	36.64999	0.006872	37.03988	
5	E	133	0.27	89.19831	0.008563	86.56376	
6	F	83	0.15	405.4562	0.022525	410.9353	
7	G	121	0.22	67.725	0.002369	63.29439	
8	H	101	0.18	143.7269	0.003369	144.6915	
9	I	134	0.29	43.76176	0.00072	42.84368	
10	K	106	0.17	206.6976	0.00248	204.2942	
11	L	128	0.27	64.47429	0.000581	61.57657	
12	M	118	0.24	52.29846	0.000363	57.05286	
13	N	125	0.22	113.1191	0.000618	117.6962	
14	JEANS	341	0.64	22.09847	9.66E-05	21.7362	
15	KHAKI	218	0.34	53.44582	0.00019	55.60837	0.9447
16	DRILL	291	0.48	26.38091	7.73E-05	26.38091	
17	SILK	61	0.2	57.75993	0.000141	59.45875	
18	JAMKAN	374	1.15	3.068132	6.31E-06	3.013344	
19	O	104	0.18	117.2049	0.000205	119.1914	
20	P	195	0.32	54.35962	8.15E-05	56.34839	
21	Q	191	0.31	61.4221	7.96E-05	64.27894	
22	R	246	0.38	42.45034	4.78E-05	42.45034	
23	S	221	0.39	30.91951	3.05E-05	31.12703	
24	T	169	0.27	92.77801	8.05E-05	95.64743	
25	U	174	0.29	67.95154	5.22E-05	67.55416	
26	Y	204	0.37	28.71328	1.96E-05	29.16193	
27	X	215	0.36	35.16409	2.14E-05	35.93411	
28	V	199	0.33	48.11536	2.63E-05	49.34909	
29	W	238	0.39	36.4266	1.79E-05	37.99093	

There is no significance difference between results of Auto-Plot tester and Shirley tester for commercial samples thus establishing the validity of Auto plot results.

SUMMARY AND CONCLUSIONS

This Auto-Plotter has been designed and developed using sensors, hardware and operating systems, which is also very portable, to test this instrument whole work has been divided into two categories

- Testing of controlled samples
- Testing of commercial samples

Forty controlled samples are generated and thirty commercial samples are selected to test and to know the validate and comparability of the Auto-Plot tester with Shirley tester.

The statistical tools such as Anova, paired mean test, Wilcoxon signed rank test and multiple correlation regression are used to know the significance differences among the samples as well as between Auto-Plot tester and Shirley.

All the controlled samples results of Auto-Plot tester and Shirley are subjected to Wilcoxon signed rank test. It clearly indicates that a very good agreement between 1, 2mm results of Auto-Plot tester and Shirley. Further because of not allowing for complete relaxation of samples (fabrics) it is showing lower agreement between 5, 10mm results of Auto-Plot tester and Shirley.

In the next step results of controlled samples are pasted with a paired mean test. From this, it is very clear that, because of different process conditions namely Scoured, Bleached and Dyed, variance difference exists. Mean hanging length of each process significantly differs from each other. As stated above the reason may be attributed todifferent process conditions of controlled samples. The bending modulus values computed for Auto-Plotter tester and Shirley tester is not significantly different, confirming the validity of Auto-Plot tester

The multiple regression coefficients are calculated for all the 29 commercial sample results of both Auto-Plot tester and Shirley the hanging length is taken at 41.5 degrees and it showed more or less same values of regression coefficients.

The Bending Modulus values of all the commercial samples also does not show any significance difference between Auto-Plotter and Shirley tester. With Auto-Plotter outputs, one can readily identify the reasons of fabric resistance to bending which is not evident with Shirley tester.

The results of Auto-Plot tester are comparable with Shirley tester. Auto Plot Tester has an advantage of examining the intermediary behavior of samples before reaching 41.5 degrees. This Auto-Plot tester has provision for storing the data's and further, it may be electronically transmitted to other sources.

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