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Influence of flock coating on bending rigidity of woven fabrics

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Abstract. This work presents the preliminary results of our efforts that focused on the effect of the flock coating on the bending rigidity of woven fabrics. For this objective, a laboratory scale flocking unit is designed and flocked samples of controlled flock density are produced. Bending rigidity of the samples with different flock densities are measured on both flocked and unflocked sides. It is shown that the bending rigidity depends on both flock density and whether the side to be measured is flocked or not. Adhesive layer thickness on the bending rigidity is shown to be dramatic. And at higher basis weights, flock density gets less effective on bending rigidity.

1. Introduction

Flock coating is a surface modification method performed on any surfaces such as metal, ceramic, wood and textile. In this method, flock fibers of chosen length and diameter are placed over an adhesive applied surface and flocked surfaces are produced. These surfaces possess a velvety structure and are used as upholstery fabrics in case the basis material is a textile fabric, for their high abrasion [1] and comfort [2] properties.

The possible applications of flocked fabrics such as upholstery and clothing materials require the flocked fabric to be flexible. One of the techniques for measurement of fabric flexibility is Shirley stiffness tester. Shirley stiffness tester measures the bending length of the fabric samples over a surface inclined at an angle of 41.5°. Bending length of the samples depend on several material properties such as fabric material (fiber type, fiber fineness, yarn count, fabric density and fabric basis weight), adhesive type (acrylic, polyurethane) and adhesive thickness. The equation given below is used to calculate bending rigidity at both weft (G_{weft}) and warp (G_{warp}) directions of the woven samples from their measured basis weights (W, g/m^2) and bending lengths (X, cm).

$$G=0.1*W(X/2)^3 \qquad (1)$$

Although abrasion [2], tensile and tearing [3] properties of flocked fabrics are investigated, bending rigidity properties of flocked fabrics are not studied to the best of our knowledge. In this study the effect of the flock coating on the bending rigidity of woven fabrics is investigated.

2. Materials and Methods

Basis material for flock application is a plain weave fabric woven from 100% cotton warp and weft yarns at yarn count of Ne 30. Basis material is supplied from the industry as desized and washed. Some properties of basis fabric are given in Table 1.

Table 1. Basis fabric properties

Basis weight (g/m^2)	Thickness (mm)	Weft density (yarn/cm)	Warp density (yarn/cm)
108	0.33	23	30

3.3dtex, 1mm length Nylon 6.6 fibers are used as flock fiber. Water based acrylic adhesive (Eracryl EMK 320) is supplied from ERKA Chemical Solutions Company and used without any other process. Adhesive is applied to the surface of the sample to be flocked by a laboratory scale coating instrument (Rapid auto coating). Since the thickness of the coating influences bending rigidity, thickness variation due to the adhesive coating is minimized by this instrument.

Flocked surfaces are mainly characterized by flock type (length, diameter) and flock density. Flock density (n) is the number of the flock fibers in millimeter square area of the sample. Since flock density changes the basis weight of the flocked samples, which is important regarding the bending rigidity, it is required to produce samples of different flock density. For that reason, a laboratory scale electrostatic flocking instrument shown in Figure 1 is designed to produce flocked surfaces of controlled flock density.

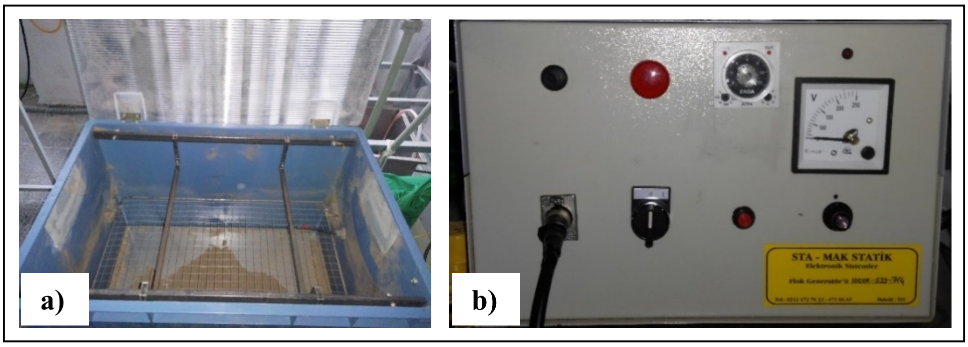

Figure 1. Electrostatic Flocking Unit. **a)** Flocking cabin, **b)** Control panel

In this instrument flock fibers stay at the bottom of flocking cabin shown in Figure 1.a, which is negatively charged, and fly to the top of the flocking cabin when a positive voltage is applied to the meshed electrode shown in Figure 1.a. From bottom to top movement of flock fibers guarantee the perpendicular placement of the fibers on the adhesive applied surface.

Control panel shown in Figure 1.b consists of on/off button, flocking duration relay and voltage relay. Flocking duration can be adjusted from 2 seconds to 12 seconds, and applied voltage can be adjusted from 10 kV to 100 kV.

In order to study the effect of the flock density and adhesive thickness on bending rigidity of flocked fabrics, two groups of samples were produced. In the first group, adhesive thickness was kept constant and flock density was changed by flocking duration. In the second group, flocking duration was kept constant at twelve seconds and adhesive thickness was changed. Sample numbers, flocking durations and adhesive thickness values are given in Table 2 and Table 3 for the 1st and 2nd group samples respectively.

Table 2. Production parameters of the 1st group samples

Group #	Sample #	Flocking duration (sec.)	Adhesive applied sample thickness (mm)	Sample #	Flocking duration (sec.)	Adhesive applied sample thickness (mm)
	1.1	2	0.38	1.4	8	0.4
1	1.2	4	0.4	1.5	10	0.41
	1.3	6	0.39	1.6	12	0.41

Table 3. Production parameters of the 2nd group samples

Group #	Sample #	Flocking duration (sec.)	Adhesive applied sample thickness (mm)
	2.1	12	0.42
2	2.2	12	0.5
	2.3	12	0.7

After adhesive application, half of the sample is flocked at the given duration and then both flocked and unflocked samples are cured at 140°C for 20 minutes. All the samples are conditioned at 65±2 % relative humidity and 21±1°C temperature for 5 hours before basis weight and thickness measurements. Flock density is measured by gravimetric method. Basis weight of the unflocked (adhesive applied) samples are subtracted from the flocked samples and the calculated weight converted to flock number by using fiber count in dtex.

Bending length of the flocked samples are measured by Shirley stiffness tester along both warp and weft directions and on both flocked side up (F) and unflocked side up (U) positions. Samples are cut in the dimensions of 2.5×5 cm. Using equation 1 for the basis weights and bending lengths, bending rigidity (G) of the samples are calculated.

3. Results and Discussion

In Table 4, basis weights and calculated flock densities of the first group samples are given.

Table 4. Flock densities of the 1st group samples

Sample #	Basis weight (g/m^2)	Flock density (n)	Sample #	Basis weight (g/m^2)	Flock density (n)
1.1	308	203	1.4	376	404
1.2	331	301	1.5	397	402
1.3	374	387	1.6	407	425

It is shown that by changing flocking duration, different flock densities are obtained. The effect of the flock density on the bending rigidity of the samples is given in Table 5.

Table 5. Bending rigidity of the 1st group samples

Sample #	G_{weft}, F (mg.cm)	G_{weft}, U (mg.cm)	G_{warp}, F (mg.cm)	G_{warp}, U (mg.cm)
Basis Fabric	65.73		123.17	
1.1	202.81	274.88	374.34	425.32
1.2	254.94	328.89	376.95	471.93
1.3	298.86	345.97	469.52	583.72
1.4	360.69	519.63	587.33	623.28
1.5	498.87	601.79	566.05	620.21
1.6	350.51	463.43	545.04	616.82

Table 5 indicates that increasing flock density results higher bending rigidity. By analyzing bending rigidity results of flocked side up (F) and unflocked side (U) measurements, it can be concluded that the samples at unflocked side up position shows higher bending rigidity. This result shows that during measurements on unflocked side up position, flock fibers resist to the bending of the sample due to friction between adjacent fibers.

Table 6. Flock densities of the 2nd group samples

Sample #	Basis weight (g/m^2)	Flock density (n)
2.1	446	452
2.2	537	423
2.3	680	420

In Table 6, basis weights and calculated flock densities of the second group samples are given. As seen in Table 6, flock densities of second group samples, which are produced at twelve second flocking duration, are close to each other. The difference in the basis weights results from adhesive layer thickness. The effect of the adhesive layer thickness on the bending rigidity of the samples is given in Table 7.

Table 7. Bending rigidity of the 2nd group samples

Sample #	G_{weft}, F (mg.cm)	G_{weft}, U (mg.cm)	G_{warp}, F (mg.cm)	G_{warp}, U (mg.cm)
Basis Fabric	65.73		123.17	
2.1	428.36	543.14	656.49	740.2
2.2	632.62	719.76	890.88	999.85
2.3	1063.17	1128.24	1302.42	1302.42

As seen in Table 7, a small increase in the adhesive layer thickness (around 0.1-0.2 mm) results a dramatic change in the bending rigidity. It is seen that direction of the measurement whether flock side is up or not is effective at the results of samples 2.1 and 2.2. On the other hand, warp direction results of sample 2.3 are identical. These results show that at higher basis weights due to thicker adhesive layer, flock density becomes less effective on the bending rigidity.

4. Conclusion

In this study, the effect of the flock coating on the bending rigidity of the plain weave fabrics was explained by changing flock density and adhesive layer thickness parameters. It was shown that by changing flocking duration, a range of flock densities were obtained.

Bending rigidity measurement showed a dependency on the measurement side of the samples whether it was flocked side up or down. Also, it was shown that the effect of the flock fibers on the rigidity decreased at higher basis weight samples.

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