THE EFFECT OF THE RELATIVE WEAVING FACTOR AND THE TEXTURE OF THE FABRIC TO THE BENDING PROPERTIES

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Abstract:
The subject of our work has been to study the drapeability of differently structured polyester fabrics and compare the flexibility of uncoated and coated fabrics. This project is connected to the corporate research of the BME Department of Polymer Engineering (Budapest) and the ESITH Research and Development Laboratory (Casablanca). The samples were analyzed with the co-created instruments of the Department of Polymer Engineering and the Department of Mechatronics, Optics and Engineering Informatics of BME, which can be used to test the draping, buckling, and bending properties of the fabrics. In the present work the relative weaving factor was used as well to characterize the difference in weaves and the bending behaviour of fabrics. The flexibility of fabrics as an important property of the wearability was tested with three methods. The bending moduli of uncoated and coated fabrics were compared as a function of the relative weaving factor.

Keywords:
relative weaving factor, fabric, bending properties, drapeability

1 INTRODUCTION

Nowadays it is an increasingly important task to design intelligent textiles. This project studies functional polymer layer coated fabrics that can be considered as composite structures. The coating contains the microscopic particles that provide intelligence due to the so-called phase-changing capsules, which can compensate the sudden temperature fluctuations during wearing.

The subject of our work is to carry out mechanical and structural tests on differently structured polyester fabrics, focusing on to compare the flexibility of the coated and the uncoated fabrics. This project is connected to the corporate research of the BME Department of Polymer Engineering (Budapest) and the ESITH Research and Development Laboratory (Casablanca).

The relative weaving factors were calculated to characterize the structure and flexibility of the fabrics,. To express the effect of weave on the deformation properties of fabrics by using the relative weaving factor is not a new idea. E.g. Geršak et al. [1] have studied the drapeability of fabrics of different weaves as a function of the relative weaving factor and found a close relationship between them. The less the relative weaving factor was, meaning the less tight structure, the less the drapebility factor was indicating the larger draping deformation.

In the present work the relative weaving factor was used as well to characterize the difference in weaves and the bending behaviour of fabrics. The flexibility of fabrics as an important property of the wearability was tested with three methods. The bending moduli of uncoated and coated fabrics were compared as a function of the relative weaving factor.

2 THE EXAMINED MATERIAL

According the Hungarian-Moroccan S&T research project we have 6 coated and 6 uncoated fabrics, because the Moroccan partner (ESITH) has the suitable material and technology for producing both the fabrics and the coated sheets. The structures of the fabrics and the composite sheets were analysed in earlier projects [7, 8, 9, 10]. The types of weaves are the following: plain, 3 types of twill, and 2 types of satin (Figure 1). These fabrics were made of specific false-twisted multifilament polyester yarn. The yarn density of the fabrics is approximately the same for both main directions, 252/100 mm in warp and 240/100 mm in weft direction (Table 1). The surface density of the fabrics is around 180 g/m^2. The coating of the fabrics was made of Dicrylan PGS foam. More information about these materials can be seen below (Table 2).

Table 1: Common properties of the fabrics

Material	**Linear density of yarns**		**Yarn density in fabrics**	
[-]	[tex]		[1/100 mm]	
PET	F_{warp}	F_{weft}	D_{warp}	D_{weft}
	33,3	33,3	252	240

Table 2: Properties of the examined fabrics

Structural properties of fabrics		**Uncoated fabric**		**Coated fabric**	
Code	**Weave**	**Thickness**	**Surface density**	**Thickness**	**Surface density**
[-]	[-]	[mm]	[g/m^2]	[mm]	[g/m^2]
1	Plain	0,41	181,19	0,34	208,82
3	Twill 1/2	0,53	180,18	0,43	207,66
4	Twill 1/3	0,56	177,74	0,44	204,85
6	Twill 2/4	0,75	180,74	0,61	208,30
7	Satin 5x5	0,72	179,76	0,59	207,18
8	Satin 5x5 reinforced	0,72	184,86	0,53	213,06

In *Figure 1* you can see the weaving type of the fabrics together with photo taken on the right side.

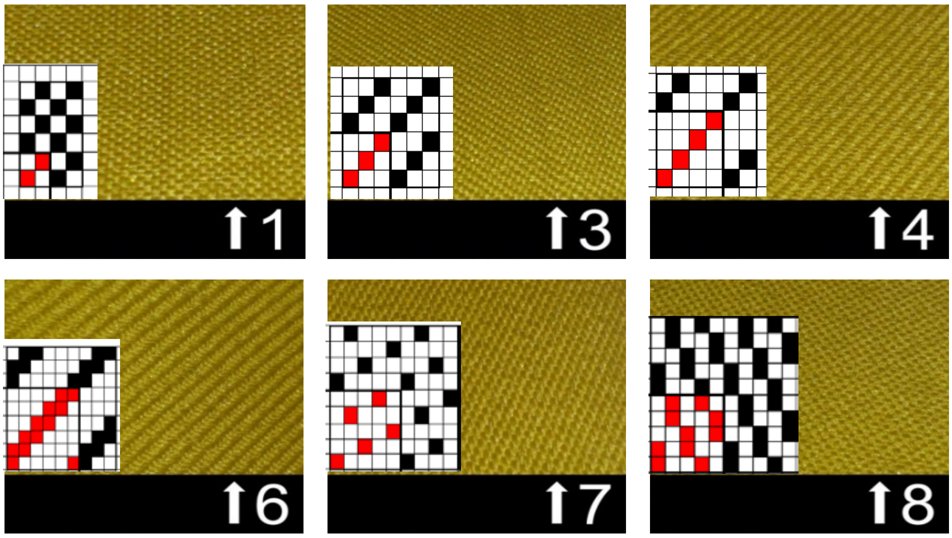


Figure 1: Weaving type of fabrics

According to our objective we have been trying to quantify the properties of the fabrics related to the weaving pattern with the relative weaving factor. It is important to emphasize the fabrics have the same properties except its weaving pattern. The relative weaving factor [3] compares the weaving factor of the examined fabric to that of plain weave, which has the same material, same density of the yarns.

In our case the relative weaving factor depends only on the weaving patterns, because these fabrics have the same properties except the patterns in order to study how the flexibility of the fabrics depends on the relative weaving factor.

The relative weaving factor can be calculated by the following equation (1):

$$X_{rel} = \frac{(\sqrt{F_{weft}}+A_{warp}\sqrt{F_{warp}})(\sqrt{F_{warp}}+A_{weft}\sqrt{F_{weft}})}{(\sqrt{F_{weft}}+\sqrt{F_{warp}})^2} \tag{1}$$

$$A_{warp} = \frac{k_{warp}}{n_{weft}}, \quad A_{weft} = \frac{k_{weft}}{n_{warp}}$$

Where:

F_{warp} and F_{weft} are the linear densities of warp and weft yarn

A_{warp} and A_{weft} are the weaving constants of warp and weft yarn

k_{warp} and k_{weft} are the average number of warp and weft yarn space-changing from right side to back side and inversely within the pattern cell of fabric

n_{warp} and n_{weft} are the average number of warp and weft yarns in the pattern cell

In case of the analysed fabrics $F_{warp} = F_{weft}$, therefore the equation is simplified to the following form:

$$X_{rel} = \frac{(1 + A_{warp}) \cdot (1 + A_{weft})}{4} \quad (2)$$

The values of the relative weaving factors are the following (Table 3):

Table 3: The relative weaving factor of the fabrics

Nr. of fabric	Weaving type	k_{warp}	k_{weft}	n_{warp}	n_{weft}	A_{warp}	A_{weft}	Relative weaving factor
[-]	[-]	[piece]	[piece]	[piece]	[piece]	[-]	[-]	[%]
1	Plain	2	2	2	2	1	1	100
3	Twill 1/2	2	2	3	3	0,66	0,66	70
4	Twill 1/3	2	2	4	4	0,50	0,50	56
6	Twill 2/4	2	2	6	6	0,33	0,33	44
7	Satin 5x5	2	2	5	5	0,40	0,40	49
8	Satin 5x5 reinforced	2	4	5	5	0,40	0,80	63

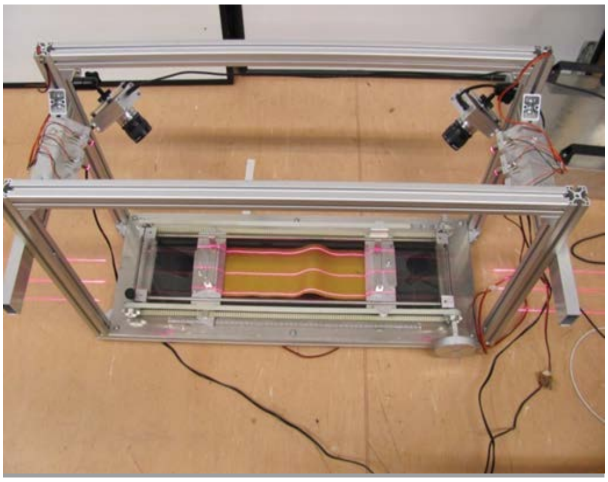
3 METHODS OF MEASUREMENTS

Three types of measuring methods were used: bending test, using Sylvie Bending Tester (Fig. 3A), draping test, using 3D Drape Tester (Fig. 3B), and bending test with Flexometer (Cantilever test) (Fig. 3C).

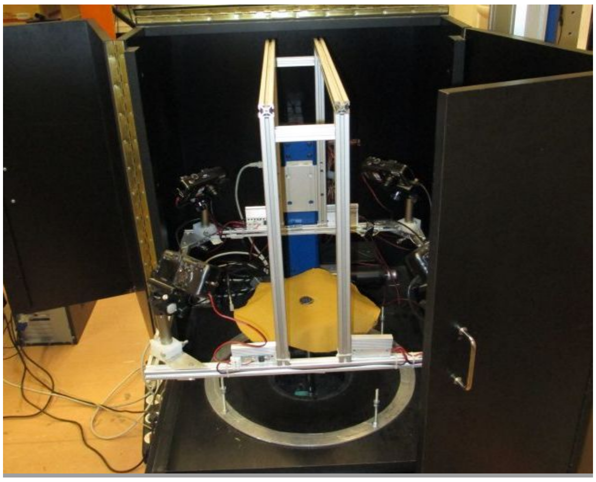
The Sylvie Bending Tester and the Sylvie 3D Drape Tester are co-created instruments of the Department of Polymer Engineering and the Department of Mechatronics, Optics and Engineering Informatics of BME. These two own-created devices which have been published in numerous previous publications [4, 5, 6, 7, 11, 12] record the shape deformation of the tested specimen via laser-scanning and determine it with computer image processing, then calculate the bending modulus and the draping coefficient from the scanned shape.

The Sylvie Bending Tester is a relatively newly developed special equipment. The used methods of the image processing and the procedure of calculating the bending modulus have been still under testing and improving. The description of used evaluation methods is published also at this conference in the paper with title of “Optical Methods for Measuring the Flexibility of Coated Fabrics” [12].

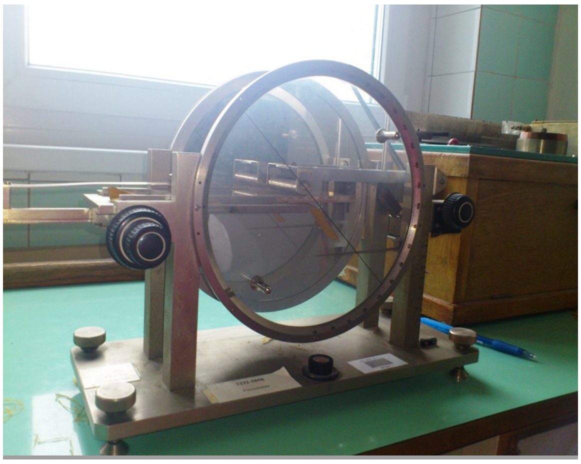
The third device is a traditional bending tester (Flexometer, Cantilever test) [1, 2], that is used to determine the "bending length" of the specimen, which is a simple way to calculate the bending modulus of elasticity. The tests with Flexometer were carried out at the Óbuda University.



A) Sylvie 3D Bending Tester



B) Sylvie 3D Drape Tester



C) Flexometer

Figure 3: Equipment used

4 RESULTS

The expected result was received by the draping tests. The relative weaving factor provides indirect information actually about the material rigidity and density. By smaller relative weaving factor the yarn crossings with changing side are fewer, therefore the fabric is more flexible than the tightly weaved fabrics as it is demonstrated by the linear trend in Figure 4. The more compact a material is, the less it will drape.

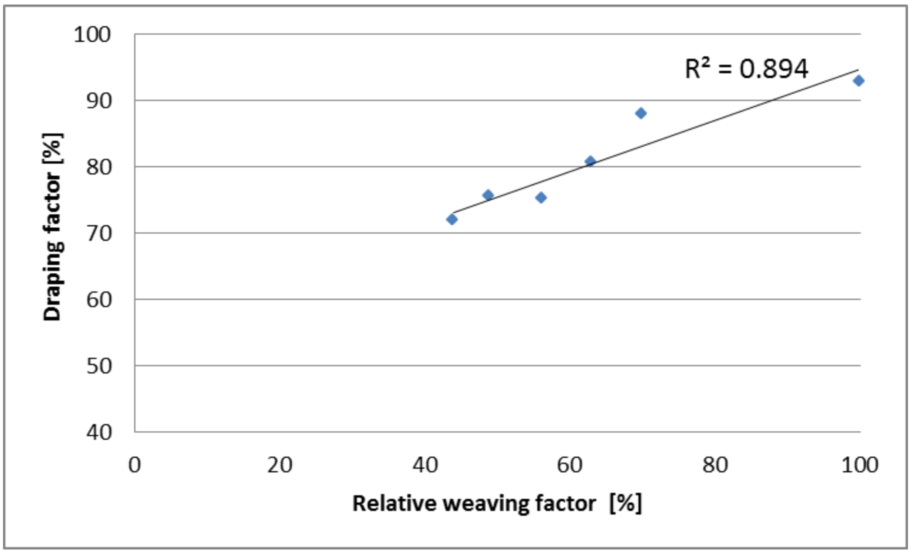


Figure 4: Drape coefficient depending on the relative weaving factor

Two measurement methods were used to determine the bending modulus of the fabrics. In *Figure 5* the values of the bending modulus are depicted as a function of the relative weaving factor. They were measured in warp direction on the uncoated fabrics. In the case of results of cantilever test lower values were obtained. However, it can be seen in both cases that the bending modulus increases with the relative weaving factor.

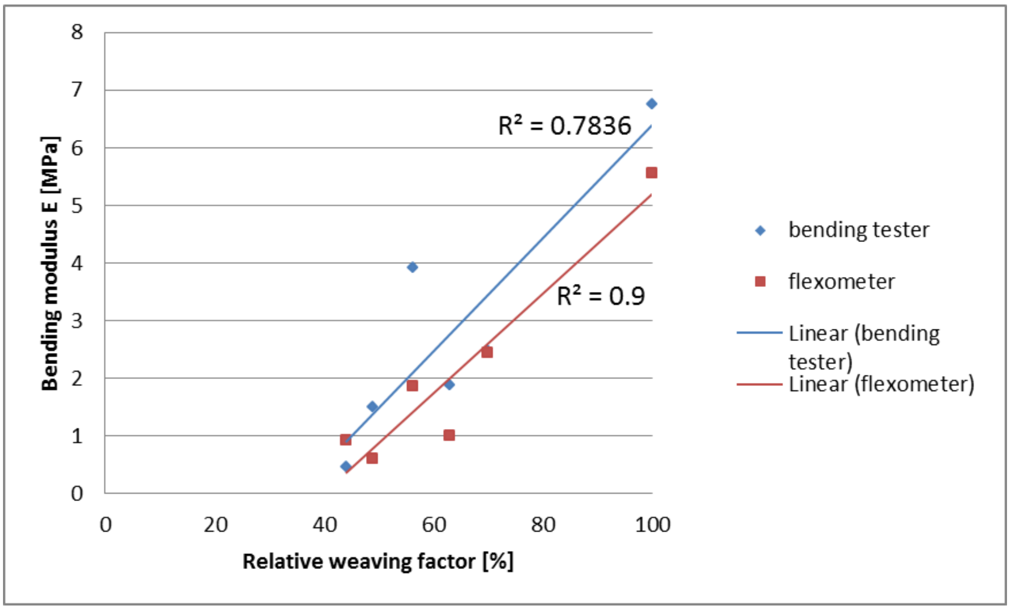


Figure 5: Bending modulus of the uncoated fabrics depending on relative weaving factor measured by Sylvie Bending Tester and Flexometer

The results of comparing the bending modulus of coated and uncoated fabrics can be seen in *Figure 6*. The measurements were carried out in three directions (in warp, in weft and in 45°) by Flexometer. In case of the coated fabrics the bending moduli are an order of magnitude higher.

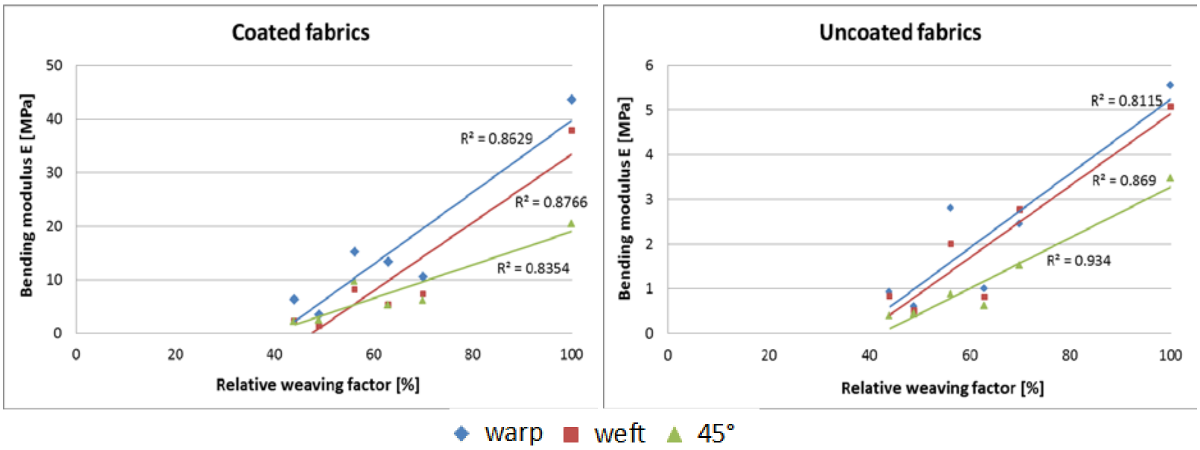


Figure 6: Bending modulus of the coated and uncoated fabrics in different directions depending on relative weaving factor measured by Flexometer

5 CONCLUSION

Our main goal was to study the relation between the drapeability and the relative weaving factor and determine how the thin coating film influences the flexibility of fabrics as an important property of the wearability of clothes. According to the results the drape coefficient increases with the relative weaving factor. The flexibility was characterized by two measuring methods. One of them is an own-developed new method to test the flexibility of fabrics. Based on the results it can be said the flexibility is greater when the relative factor decreases. Since in general the flexible material is more comfortable than the more rigid hence fabrics of the lowest weaving factor should be chosen for coated cloth materials.

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