Textiles dynamically influenced drapability

Bidour Al-Gaadi[1,a], Marianna Halász[1,b] and Péter Tamás[2,c]

[1,2]Budapest University of Technology and Economics

[1]Department of Polymer Engineering, Műegyetem rkp. 3., T. bldg. 311., Budapest, Hungary, H-1111

[2]Department of Mechatronics, Optics and Engineering Informatics, Bertalan Lajos u. 4-6., D bldg. 407., Budapest, Hungary, H-1111

[a]al-gaadi@pt.bme.hu, [b]halaszm@pt.bme.hu, [c]tamas@mogi.bme.hu

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Abstract. Many researchers examined the static drapeability of textiles, they found that the textiles with different materials, structures or finishing have different drape characteristic. They analyzed also apart the static measuring the drapeability influenced with dynamical effect. They measured the dynamic drapeability during rotating the textile sample [1]. They found that the form of the draped sample is change from the dynamic effect. The Sylvie 3D Drape Tester developed at BUTE record all the surface of draped textiles with scanning technology, and the evaluating computer system define the usual drapeability parameters, like node number and drape coefficient. We complete the equipment with a tool with which we can examine the drapeability after different exactly defined dynamic effect.

Introduction

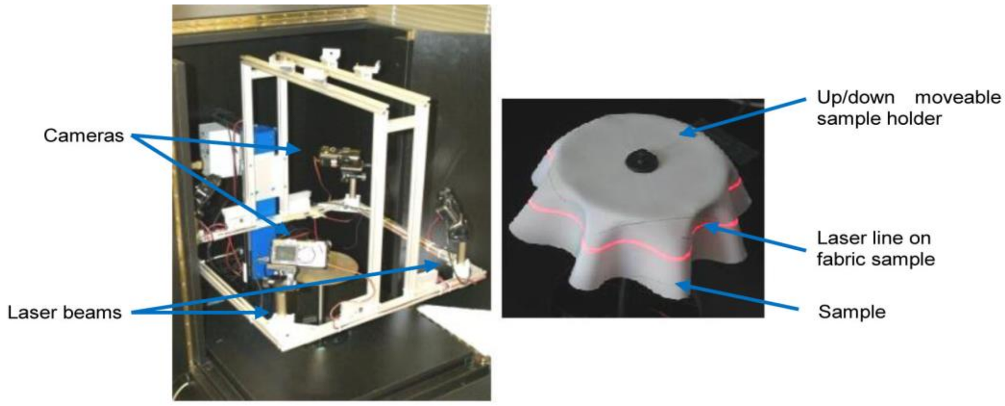
The drape measuring systems are popular to determine the textiles properties. The measured results are usable to simulate the drapeability of textiles. But there is a problem with the standard deviation of the measured parameters and with knowing the reason of it. At the examination of drapeability from the textile side the material, the structure, the finishing and from the examination side the mechanical effect influence the results of measurement.

The Sylvie 3D Drape Tester developed at BUTE oppositely to the popular Cusick drapemeter, record all the surface of draped textiles with scanning technology, and the evaluating computer system define the usual drapeability data, like node number and drape coefficient. According to the literature we suppose that the drapeability of textiles will different at different levels of stress.

We completed the equipment with a tool with which we can examine the drapeability after different exactly defined dynamic effect. The tool is a ring, and there are two rings with different diameter. We introduce the completed equipment, and the dynamic effect of completed equipment on the textile sample and the analysis of the results of those measurements.

Measuring system

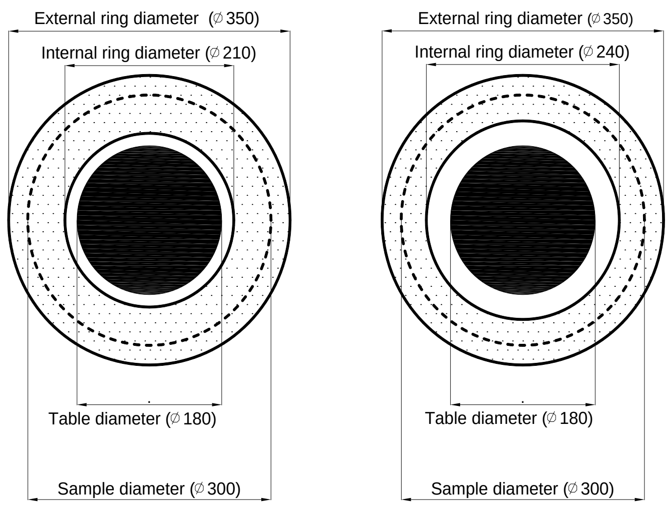
The table part of the Sylvie 3D Drape Tester equipment (1. Figure) is in the starting state is in the same level that the base plate. The table have diameter 180 mm. The fabric sample have 300 mm diameter. We have to put the centre of the sample punctually on the centre of the table, and warp and weft direction have to be parallel with the specified direction. A computer controlled engine lift up the table, assuring that the drapeability take shape always with the same speed and between the same dynamic effects. During the measurement 4 laser beams project leaser line on the fabric sample determining a cross section. 4 cameras record those lines which are over the laser beams. The cameras and the laser beams are on a measuring frame. The frame moves with a determined step distance during scanning the surface of fabric sample. The computer controlled instrument is constructed in a black box, assuring that during the measure there is dark. After all photography the computer downloads the pictures [2].



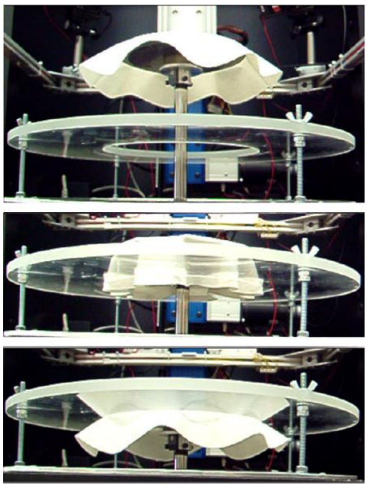
1. Figure Sylvie 3D Drape Tester

Completing tool

To examine the dynamical effect on the fabric sample we completed the instrument with special tool with different dimension. The tool is a ring with different internal diameter. The external diameter of both of ring is 350 mm, one of them have 240 mm internal diameter, the other one have internal diameter 210 mm (Figure). When the table moves up the fabric sample are drawn through the inner hole of rings (3. Figure). During drawn through the ring the fabric have a dynamic effect. We suppose that the ring with smaller internal diameter makes bigger dynamical effect on the drapeability of fabric drape [3].



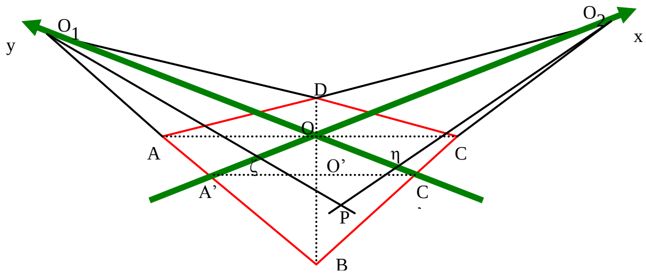
2. Figure Instrument completing rings dimensions



3. Figure Ring completed measurement steps

Iterative calibration

The task of the frame is the definition of the points on a two-dimensional curve based on photos. Points of the curve are defined by picture processing methods. The question is only how to define the 3D position of points upon the photo. In order to find the non-linear bijection between the photo and the 3D plane, we used an iterative calibration. Take a photo of a square by defined dimensions. Corners of the square are *A*, *B*, *C* and *D* in order (4 Figure). Let the origin of *x*-*y* planar coordinate-system *O* be the centre of the square (intersection of diagonals)! The question is how to define ζ and η coordinates an optional *P* point.



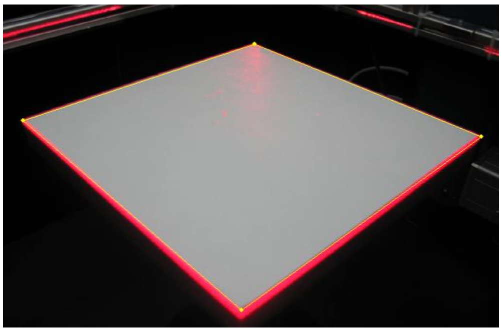
4 Figure Geometry of the iterative calibration

As the projective mapping *AB* and *CD* parallel lines are crossing at O_1 point, *AD* and *BC* lines are crossing in O_2 point. *X*-axis of the coordinate system with *O* origin goes through O_2 like the y axis goes through the O1 point. Accordingly the image of x-axis is the OO2 line and the image of y-axis is the OO1 line. Image of the coordinate line of P point parallel by the y-axis goes through P and O_1 like image of x-coordinate line goes through P and O_2. They cross the axes at ζ and η. Due to the nonlinear mapping with unknown parameters there is no direct formula. The real 3D and the photo positions of *A*, *B*, *C*, *D* points and *O* origin are known. Coordinate axes divide the square up to four quadrants. One of them contains the *P* point. Corners of the quadrants are known, for example *x*-coordinate of *C'* is *0* and *y*-coordinate is the same as the y coordinate of known *B* point, analogous y coordinate of *A'* is *0*, and *x*-coordinate is the same as the *x*-coordinate of known *A* point. At first sight we are not closer to the solution, but the size of the side of the *A'BC'O* square is the half of what it was in case of *ABCD* square. We can estimate coordinates of *P* point better (ζ coordinate is between *A'* and *O* and η coordinate is between *O* and *C'*). *O'* origin of the new *A'BC'O* square can be defined by the intersection of *A'C'* and *OB* diagonals. By the *O'* origin we can divide *A'BC'O* square up four quadrant again. One of them contains the *P* point giving a better estimation. We can go on dividing squares. It is all the same which quadrant contains the *P* point. The special situation above is used only because of the figure. By refining the subdivison better and better estimation can be taken about the original ζ and η coordinates. The photo resolution is the only limit.

Position of every *P* point can be defined by help of *A*, *B*, *C* and *D* calibrating points. The iteration is easy to program. It is a quick coordinate defining algorithm.

Measuring by the Equipment

Laser beams light a planar curve in every position of the frame. Points of curve are defined by processing of four pictures. For 3D scanning the plane to plane perspective transformation is bijection. The real corners of a rectangular calibration element and the computed corner positions by iterative calculation process [4] are shown in 5. Figure.



5. Figure. Quadrangle of the calibration

There is an automated corner based calibration process integrated. Determination of corner coordinates starts at the corner closest to the actual camera. If we define the point of the edge image in the coordinate system connected to the left-bottom corner of the photo then regression lines can be defined for every x_s on section $x<x_s$ and $x>x_s$. Let the error of the regression H is a function of x_s! In other words $H(x_s)$ is the sum of the differences of y_i point coordinates and the $a*x_i+b$ lines with unknown parameters (x_i are point coordinates) in front of the corner and behind the corner (1).

$$H(x_s) = \sum_{x_i<x_s}(y_i - (a_{x<x_s} x_i + b_{x<x_s}))^2 + \sum_{x_i>x_s}(y_i - (a_{x>x_s} x_i + b_{x>x_s} x_i))^2 \qquad (1)$$

Minimum of $H(x)$ will be at the real position of the corner at x^*. Substituted back on $x<x_S$, or $x>x_S$ section y^* will be identifiable. Coordinates farthest away from the camera can be counted similarly. The only difference is that regression lines should be searched on the edges of the square. Corner points on the left and right sides are derived as the intersections of the defined regression lines. By calibration data the point-cloud of surface points are measured and edge points are determined by picture processing methods.

3D Reconstruction

Edge curve is approached by a slice of Fourier series [5] in the cylindrical coordinate system Eq. (2). Size of the slice (n) can be defined by the software.

$$\begin{bmatrix} R \\ z \end{bmatrix}(\varphi) = \frac{1}{2}\begin{bmatrix} a_{R0} \\ a_{z0} \end{bmatrix} + \sum_{i=1}^{n}\begin{bmatrix} a_{Ri} \\ a_{zi} \end{bmatrix}\cos(i\varphi) + \sum_{i=1}^{n}\begin{bmatrix} b_{Ri} \\ b_{zi} \end{bmatrix}\sin(i\varphi) \qquad (2)$$

Fourier coefficients are defined by least square method. If the N measured cross-edge points of the actual level are $([R_k, z_k]^T, \varphi_k)$ then the a_{Ri}, b_{Ri}, a_{zi}, b_{zi} coefficients are defined by the minimum of a functions Eq. (3) and Eq. (4).

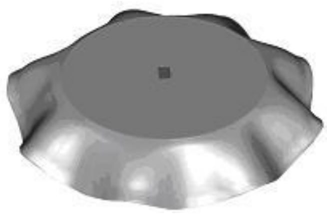
$$\sum_{k=1}^{N}\left\{R_k - \left[\frac{1}{2}a_{R0} + \sum_{i=1}^{n} a_{Ri}\cos(i\varphi_k) + \sum_{i=1}^{n} b_{Ri}\sin(i\varphi_k)\right]\right\}^2 = \min \qquad (3)$$

$$\sum_{k=1}^{N}\left\{z_k-\left[\frac{1}{2}a_{z0}+\sum_{i=1}^{n}a_{zi}\cos(i\varphi_k)+\sum_{i=1}^{n}b_{zi}\sin(i\varphi_k)\right]\right\}^2=\min \tag{4}$$

Upon $z(\varphi)$ function of edge curve $z_i(\varphi)$ level functions (i=0…n) can be defined by Eq. (5).

$$z_i(\varphi)=i\,\frac{z(\varphi)}{n} \tag{5}$$

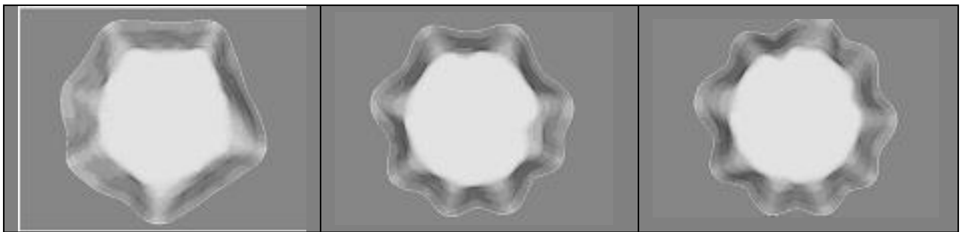
With help of $z_i(\varphi)$ function point-cloud is processed and $R_i(\varphi)$ functions are approached by Fourier slices as it was shown in Eq. (2). Geometry of the sample is modelled by Bezier surface patches. Control points of patches are on level curves. Patches are connected to each other continuously in first order by the Catmull-Romm model. Edge slopes are defined by the vertices of the actual element, too [6] (6. Figure).



6. Figure The Approximated Geometry

Strain situation simulating with different rings

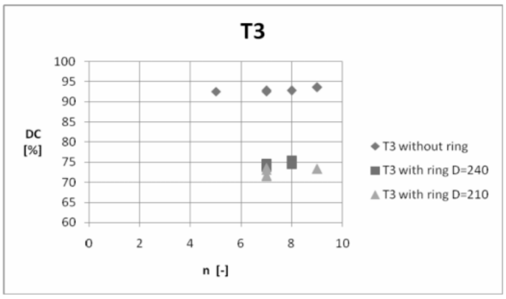
Different dynamic stress situations are modeled rings with different inner diameter. When the table moves up the test-materials are drawn through the inner hole of rings. If we measure without any ring, then the draping process is quasi static. Measuring with different rings simulates throwing the material on the table with different velocity. It is closer to a real wearing situation.



No ring	Ring D240	Ring D210

7. Figure Measuring with different rings

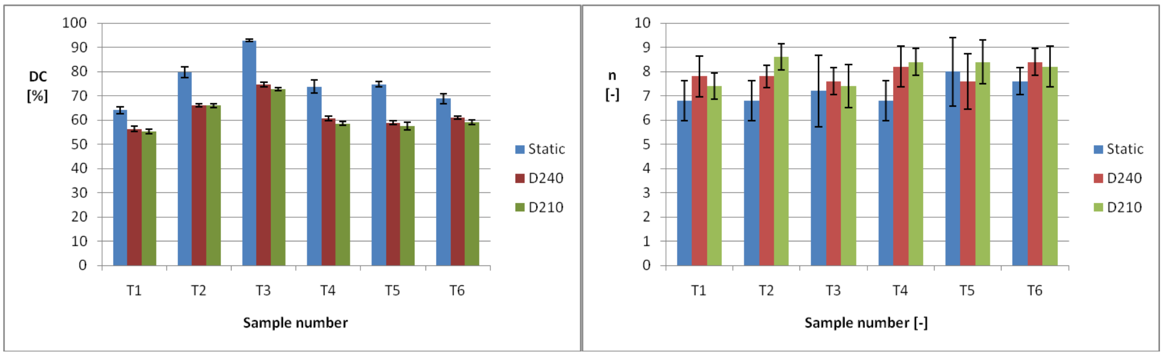
Draping ratio and wavelength of the edge curve of material are decreasing, the number of waves is increasing and draping geometry shape is moderated when rings are used. The smaller inner radius makes more influences. Figure 7 shows the different resulting simulations while Figure 8 shows the function of the draping coefficient of the inner radius of the rings.



8. Figure Drape coefficient (DC) as the function of the ring diameter (D) in some measuring process

Results

We measured 6 different cotton samples, the difference is in the yarn twist direction shown in Figure 9.



9. Figure Drape coefficions and vawe numbers

Summary

Our equipment measures drapeability of materials in different strain situation well.

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