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MECHANICAL CHARACTERISATION FOR NONWOVEN FLAX/PP AND 3DMODELLING OF THE GARMENT CREATION PROCESS

Francine Roudet*[1,2]*, Assistant Professor, David Sueur*[1]*, International Coordinator
Pascal Bruniaux*[1, 3]*, Professor
[1]*University of Lille, Nord de France, Lille, France*
[2]*LGCgE, Nord de France, Lille, France*
[3]*Ecole Nationale Supérieure des Arts et Industries Textiles, GEMTEX, Roubaix, France*

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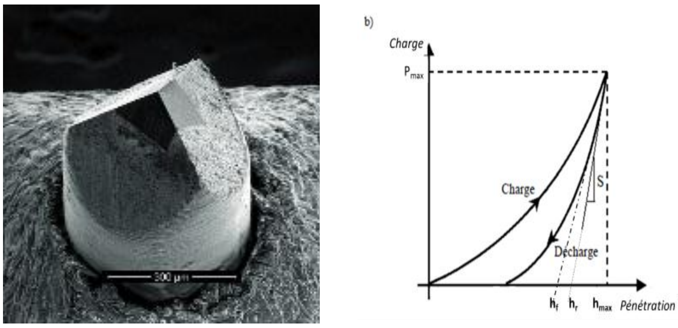
Abstract. *The use of natural fibers is more and more usual in the automotive industry. One of the interesting properties of flax is its acoustic absorption and the impact on the environment. Non-woven flax/PP is used for example in the door trim of Citroën C4 Picasso. One problem for this new compound is how to characterize mechanical properties. This work will expose how indentation tests can give information such as hardness and Young modulus.*

Another part of the work will be devoted to the implementation of a new design process of the garment fit the body in a 3D digital environment. This method is based on the analysis of 2D pattern-making methods used by model makers. These methods highlight the morphological and anthropometric links that we have used to develop a similar method in 3D. The difference is that we work directly on the 3D client's morphology which avoids morphological interpretation errors.

Part 1: Mechanical characterization for nonwoven flax/PP

Nowadays, we are more often interested in developing new lightweight materials having better mechanical performance while reducing the economic impact of their development. The interest of this study, is to replace carbon fiber by flax fiber, and epoxy resin by polypropylene and define the mechanical properties as Young modulus and hardness, using instrumented indentation test. This bio composite (flax/PP) is a nonwoven material, lightweight and less expensive.

Instrumented indentation test consists in indenting a material with a pyramidal tip with a specific load during a set time. Micro and macro indentation tests were carried out. The curve of load-displacement is recorded. From the unloading part of the curve Young modulus can be defined. (Fig1).



h_{max} : Maximum depth at the maximum load P_{max}

h_r : Residual depth obtain by the tangential of unloading curve

h_f : Residual depth carried out by plotting unloading curve

S:Contact stiffness (Deformationof the machine)

Figure 1 – Pyramidal tip and load-displacement curve

Hardness (H) and Young modulus (E) are defined using the following equation 1, where A_c is the area of contact between the indenter and the material.

$$H = \frac{P_{Max}}{A_c} \qquad and \qquad E = \frac{S}{2}\sqrt{\frac{\pi}{A_c}} \qquad \text{Equation (1)}$$

Chicot et al. [CHI14] propose a relation to determine$A_c$based on two physical factors $h_C$and h_b. Where h_C is the contact distance between the indenter and the material, and $h_b$is the tip default coming from its wearing (equation 2).

$$A_C = 24{,}5\left[h_C + h_b\left(1 - exp\left[-2\frac{h_C}{h_b}\right]\right)^{\frac{3}{2}}\right]^2 \qquad \text{Equation (2)}$$

Based on equations (2) and (1), it is possible to plot H andE for non-woven flax/PP in micro or macro indentation tests. On figure 2, the no-woven flax/PP can be model by brown and blue curves.

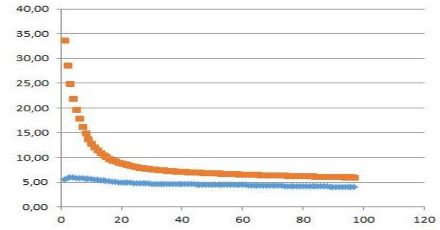
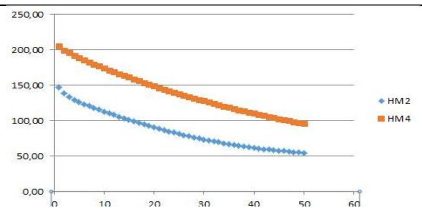
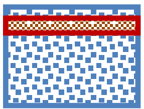
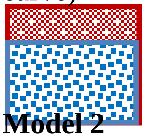
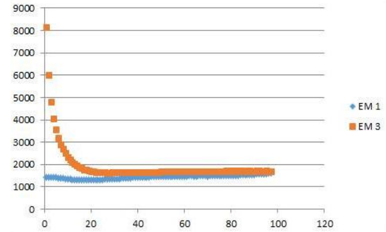
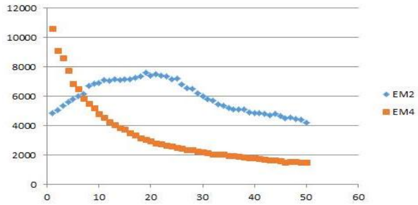
<table>
<tr><th></th><th>Macro-indentation tests</th><th>Micro-indentation tests</th><th>Model</th></tr>
<tr><td>Hardness (MPa)</td><td>
</td><td>
</td><td rowspan="2">▨ Flax
▨ PP

Model 1(Brown curve)

Model 2 (Blue curve)</td></tr>
<tr><td>Young Modulus (MPa)</td><td>
</td><td>
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Figure 2 – Evolution of Hardness or Young modulus vs indentation depth

In macro-indentation tests, on the surface of the specimen, H and Ecurves describe a behaviour of the bio composite as Model 1. On the surface of the sample, the properties of PP are extracted and are 35 MPa for H and 8 GPa for E. While, Model2 give information of flax as 5 MPa for H and 1.3GPa for E. At around 20nm the global properties of the no-woven flax/PP can be extrapolated as 6.5 MPa for H and 1.8 GP for E, in both types of indentation. In micro-indentation tests, due to the heterogeneity of the material, for 8 nm depth, E change from Model 1 to Model 2.

From instrumented indentation, it is possible to separate mechanicalbehaviour of the no-woven flax/PP and have access of the global properties.

Part 2: 3D modelling of the garment creation process

Customized clothing has become trendy nowadays, and some brandsalready propose customized shirts and jeans. To reach a mass production level, industrials have to modify the way to think garments. *One solution consists in using scans of a reference body and garments that enable the evaluation of the overall 3D ease of the garment*. The final goal is to offer personalized products with costs close to the mass production [THO13]. Anthropometry is another important factor to take into account. It is unique for each individual and depends on the postnatal diet or exercise for example [CIC14].

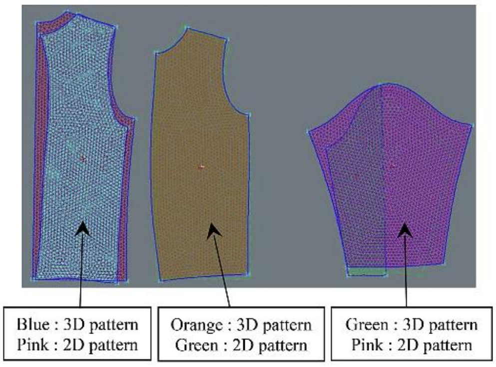

Figure 1 – Comparison of patterns for validation

The process of our work is to provide to designers an efficient and reliable method to quantify the ease allowance when garments are designed in 3D, and to check the whole process of design in 3D with the computed ease allowance. The men's basic bodice methodology developed can be arranged in five sequences: reference body, body scanner, post processing, 3D design platform and 2D pattern making. The last step gives information to valid the 3D environment, it is interesting to note that it is advisable to work with the help of parametric lines. In fi-gure 1, 3D pattern was compared to commercial software *Design Concept* from *Lectra*company. We observed that the patterns flattened in 3D get closer to 2D but are somewhat different. The problem arises due to the lack of knowledge of spatial parameters while defining the ease contours around the body, i.e. exact distance between the body and the garment.

Anthropometry data is changing because of the modification of life-style, nutrition and ethnic composition of populations. That is why to create garments, it is important to move towards 3D environment allowing to obtain industrial garment patterns. Due to the given limitation and computational weakness we faced, we adopted a reverse process in which we first carried out a perfectly fitted garment for the subject and tried to revert to the design phase in 3D. The method can be described in 8 phases: (a) Taking measurements and marking the intersection points of the garment with the body, (b) Scanning the body with and without the garment, (c) and (d) Obtaining the body planes across predefined parametric contours, (e) Superimposition of the images, (f) Division of space between garment and body, (g) Calculating the distance between body and garment. Figure 2 gives the result of the method for a sleeve. Then, the 3D construction of the whole garment was performed according to the proposed methodology.

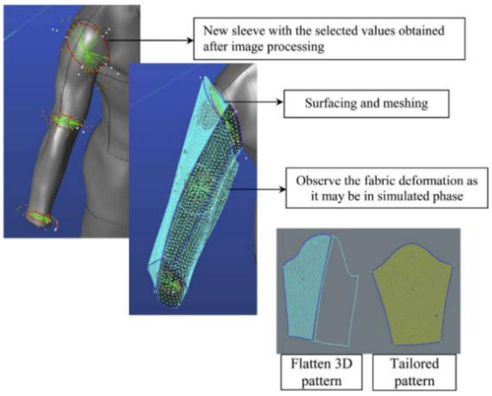

Figure 2 – Construction the new sleeve with computed values

This new approach was implanted into an industrial CAD solution to verify the correct 3D garment, and manage the size of the adaptive mannequin according to the sizing chart. The morphology [LOO43] of the mannequin may vary according to morphological parameters of: (a) the limb length or height of the avatar, (b) the volume, (c) control parameters, and (d) of volume distribution between the front and the back of the avatar.

The simulation software enables experts in pattern making to check if the garments fits well in terms of ease, balance and ratio. It also enables to simulate a wide variety of fabrics with different drape properties. In addition, the adaptive mannequin morphology model follows the body morphology from the scan.

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