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COMPUTATIONAL ASPECTS ABOUT THE MULTISCALE MODELLING OF TEXTILE WOUND STRUCTURES

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The textile wound packages are known from the daily use probably mainly from the sewing yarn bobbins, but they are very important and very intensively used pre-product in the textile chain for winding the yarns, storing for certain time, transportation and setting on the next machine. The quality of the wound packages is determined by its stability, regularity of the windings and some more advanced parameters as for instance the stress distribution, which influences the stability and the yarn relaxation processes. In the last decades, the winding theory and generally the problems and algorithms for computations around the winding process were extended and investigated as well for a completely new application – the composites winding.
From the macro-mechanical point of view the winding of textile yarns and winding of glass or carbon tows during the composites winding are analogous processes. At that level, the yarn is considered as one-dimensional continuum and the yarn cross section is neglected (Figure 1). The analytical equations of the winding kinematics for such cases can be found for instance in [4] and some computational approach for composites winding in [1,2,3]. These equations describe mainly the coordinates of the winding point, depending on the motion of the yarn guide and the process geometry.

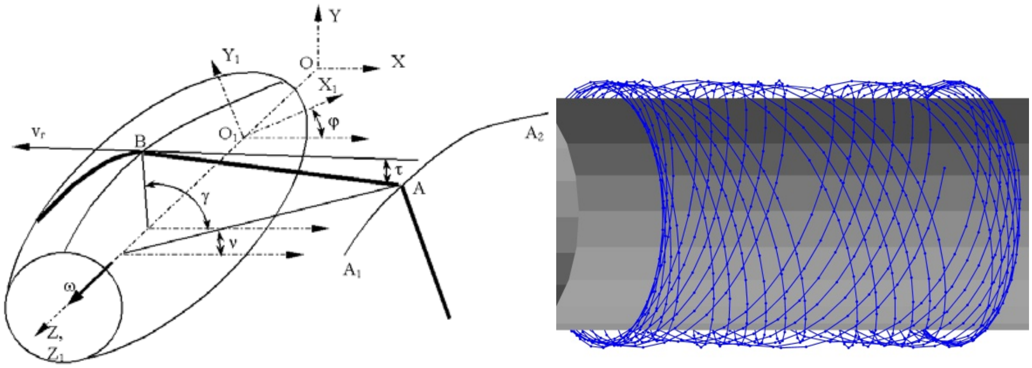

Figure 1. General geometry of the winding process following [4]. The yarn guide A is moving along the curve A_1A_2, the winding point B is the current first fixed point of the yarn over the bobbin surface. The bobbin rotate with angular velocity ω ; b)simulated yarn path during the winding

At mezo- and micro scales, where the yarn cross section should be considered as deformable or even the single filaments have to be considered, respectively, the modelling for composites winding and the textiles winding already differs significantly. In the commonly used yarns for composites, like Glass and Carbon the cross section of the yarn can change its form, but is very stiff on lateral pressure, the textile yarns or the fiber sliver in the spinning preparation processes are soft and easy compressible.

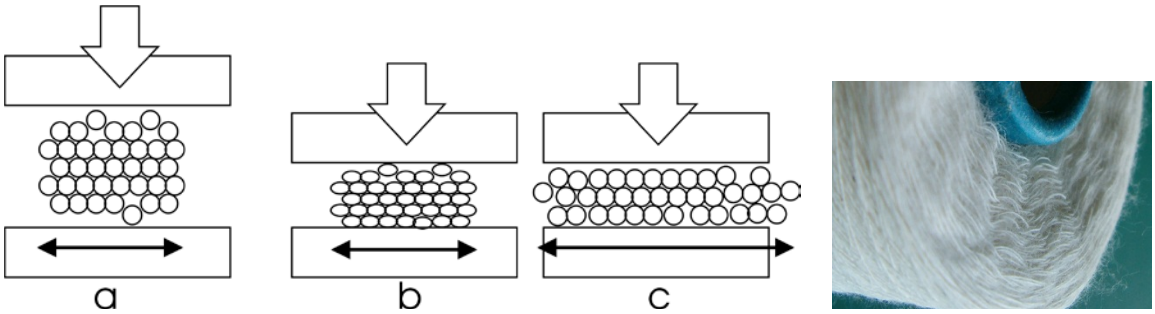

Figure 2. Changes of the yarn cross section a) initial cross section of multifilament yarn, b) deformed cross section of compressible yarn c) "deformed" or more precisely rearranged cross section of incompressible yarn d) compressed windings inside of the bobbin as result of not correct chosen winding tension.

The modelling of compressible yarns requires exact information about the lateral compressibility behaviour of the yarns and at both levels yarn and bobbin the deformations during the winding should be taken into account. For materials which show significant relaxation process, the changes in the stress state in the bobbin as result of the relaxation should be simulated as well in order the final state to be estimated correctly.

Contrary, the single filaments in the yarns with straights filaments (no crimp, to texturing, no staple yarns) changes their position in the cross section (Figure 2c) making it more flat. This process can be efficiently modelled if the complete contact between the single filaments is taken into account. Considering that one 50k Carbon rowing consists of 50 000 single filaments, is clear, that the algorithms should be developed efficient in order to receive useful results in normal time. Some more issues and original numerical examples, demonstrating some contact search problems, data storage issues and combination of the information from the mezo scale to the boundary value problem of ordinary differential equation at macro scale are included.

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