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MODELING OF HIGH PRESSURE COMPOSITE VESSELS

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Summary: The high pressure composite vessels are made out of composite material reinforced with carbon fibers. The vessels are manufactured by filament winding process, therefore mechanical properties of such composite depend strongly on the winding structure. Determining elastic parameters of these materials is an important issue. The most popular method is an experimental one, however it is expensive. Alternative method is homogenization of the materials parameters. Homogenization allows determining materials parameters base on known properties of composite phases, such as matrix and reinforcement. The numerical homogenization method allows to model complex geometry like filament winging pattern. It can be jointly used with other micromechanical models. In case of the composites reinforced with fibers useful are methods assuming periodicity of the structure. Composites possessing periodic structure can be described with use of the Eshelby method extended with implementation of cyclic boundary conditions. First stage of homogenization is used to determine mechanical properties of composite bundle with uniaxial aligned fibers. In the second stage, when effective material properties of the composite bundle are known, it is possible to extract next representative cell describing roving structure. Also material properties are known – spring constants of every phase.
Second stage of homogenization is used for determination of effective material properties of the composite reinforced with fibers. From the first stage of homogenization effective material properties of the composite bundle are known. Also material properties of the matrix are known. Because of the complex shape of the representative cell numerical homogenization seems most effective.
In here FEM is used what allows modeling of RVE with complex geometry.
Complicated construction and complex aspects related to the production method make them very problematic. Composite pressure vessel is made of liner, boss and composite roving that works as a load carrying layer. Designing of the composite roving is the biggest challenge because it requires taking into consideration strength aspects (optimal fiber placement on the body and dome of the vessel) and also very important aspects related to the manufacturing technology such as slipping of fibers from the dome, proper impregnation of fibers, deciding on the thickness of the roving, etc. It should be considered that strength and technical aspects are closely related and optimal designing of the composite vessel is impossible without taking into consideration both of them. Number of parameters determining strength of the composite vessel (thickness of the roving layers, number of layers, winding direction, number of interlaces, etc.) is a basic challenge during designing of the optimal structure.