Workshop 1

Mechanics of Materials and Structures

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Innovations in technological applications increasingly demand that the properties of the materials are exploited to the fullest extent. Classically, materials used in engineering applications are used up to their elastic limit. The increased understanding of material behavior starting from the initial linear elastic regime up to and including failure has facilitated the design of technological applications in which the entire load-carrying capacity of materials is being used. The accurate simulation of material behaviour still plays a central role in this development. The research groups at TUD, TUE and UT all contribute, via various research directions, to a continuously increasing understanding of material behaviour at all length scales.

The accurate description of material behaviour on a specific length scale (say, the macro level) often requires an analysis of all deformation stages (linear and non-linear up to failure) on a smaller length scale (say, the micro level). The analysis of the micro level requires an accurate knowledge of the structure of the material as well as constitutive models for all relevant physical processes on this level. Depending on the specific application, research paths may focus on (I) an adequate simulation of the structure of the material, (ii) the formulation of material models that capture the relevant physical phenomena on the micro level, (iii) homogenisation procedures that facilitate the formulation of constitutive models on the macro level in which all relevant physical phenomena are accounted for, (iv) the identification of material parameters that occur in the material models and (v) the proper use of the model in the design of technological applications. The workshop will address all these topics through selected contributions from all participating universities.

The simulation of the structure of man-made materials, for example non-crimp fabrics, is addressed in the contribution by ten Thije. This work focuses on the formulation of a finite element model that simulates the draping process of the fabric. The outcome of the model, i.e., the geometry and the final orientation of the fibre bundles, may be used to predict problem regions during the draping process. Once the structure of a material on the relevant micro level is determined, constitutive relations are formulated that capture all relevant physical phenomena. Based on the predicted geometry, Loendersloot et al. are able to apply a model built for the prediction of the permeability of non-crimp fabrics which facilitates a better simulation of the mould filling during the production process. The contribution from Janssen et al. addresses the formulation of a single parameter material model for glassy polymers based on the Leonov model that accounts for progressive aging. The contribution from Viatkina et al. focuses on the formulation of a dislocation cell structure model that is able to describe the changes in dislocation structures as a result of strain path changes. The contribution of Driessen et al. focuses on the formulation of a material model for biological tissue that both accounts for and predicts the change in orientation of the fibrillar structure of the material.

The analysis on the micro-level is followed by a formulation of models on the macro level in a way that preserves all relevant information for this level. The workshop provides two contributions that focus on this transition. The contribution from Fatemi and Van Keulen focuses on the formulation of a constitutive model for cancellous bone based on a Cosserat continuum model. The transition to the macro level is done a priori using either a Cosserat homogenisation approach or an optimisation-based approach. These approaches yield the elastic Cosserat moduli for the macro level. The contribution from Kouznetsova et al. addresses a numerical homogenisation approach that facilitates the homogenisation of the relevant micro level processes in cases where the scale of the micro level is not negligible to the scale of the macro level.

The design of innovative technological applications relies on the formulation of predictive macro level material models. The analysis of the micro-level and subsequent transition to the macro-level provides all relevant data needed for the specific case being considered. Another approach is the formulation of a generic material model applicable to a class of materials and phenomena on the macro level and the subsequent determination of material parameters that best apply to a specific problem. The contribution to the workshop from Iacono et al. addresses this issue. Their work focuses on the formulation of an inverse problem that yields the best set of model parameters through the minimization of a function that captures both local and global information of the deformation processes. The contribution of Langelaar and Van Keulen focuses on the formulation of a material model for a specific class of martensitic phase transformations, i.e. the R-phase transition in NiTi, suitable for the design of micro-actuators. Finally, the contribution from Pasaribu et al. shows an example of micro-macro property relation in an experimental study on friction reduction in alumina and zirconia ceramics by the addition of copper oxide.