2nd International Workshop on Software Solutions for Integrated Computational Materials Engineering

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Sandbox Scenario 5

Production of parts made of discontinuous fiber composites materials

Introduction

Discontinuous Fibre Composites (DFC) are heterogeneous systems made of strands coming from a chopped pristine unidirectional (UD) tape, Figure 1 left. This class of material continues to gain interest in aerospace applications as well as in other industrial sectors.

Such materials are well suited for compression moulding while achieving good stiffness performances, Figure 1 right. Compression moulding is of particular importance for the aerospace industry has it allows the production of both (net-shape) thin and bulky/3D parts at high rates. This process will then allow the reduction of production costs and the possibility to increase the percentage of composite materials present in structural aerospace parts for weight reduction.

Figure 1: Chips of DFC and examples of produced parts.

DFC have numerous advantages over classical Quasi-Isotropic Laminates (QIL) in terms of both ease of processing and stiffness. However, the first studies conducted on them demonstrated that the strength of DFC is usually quite below the one of QIL. This phenomenon is linked to the inherent heterogeneity of the meso-structure. The meso-structure is induced by the process such that its prediction for later structural analysis is of tremendous importance. Correspondingly, the modeling of the polymer resin (that can be thermos-set or thermos-plastic) is of tremendous importance. Indeed the resin flow, depending of the polymer structure (see Figure 2) and its evolution during the process, its viscosity, governs not only the fiber orientation but also part of the end performance of the produced part.

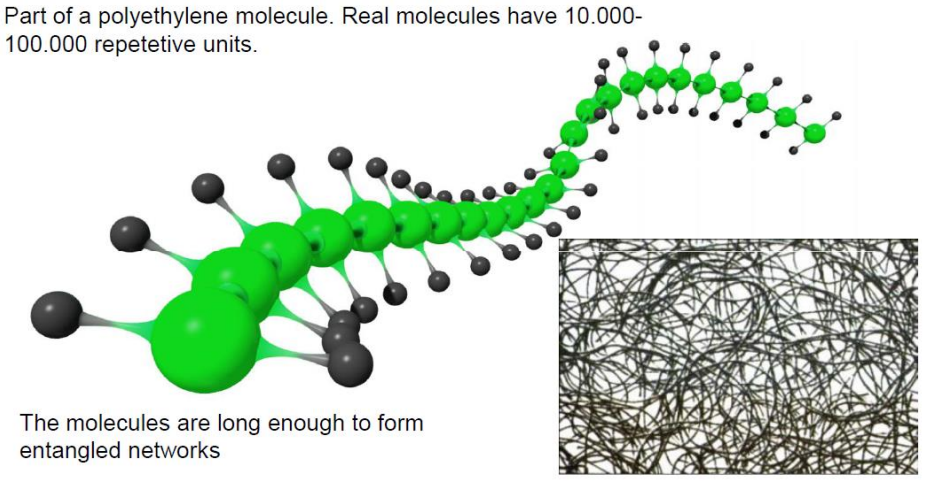

Figure 2: Molecular structure of polymer chains.

The modeling chain has to contain most of the following modeling stages, Figure 3:

- Polymer level simulation allowing predicting polymer structure and properties.
- Process model, including microstructure models, allowing predicting the material structure (polymer and fibers) across the part following the process conditions.
- Material models allowing predicting material stiffness and strength at every location of the product, accounting for local microstructure.
- Structural model accounting for spatially varying material properties as induced by the process.

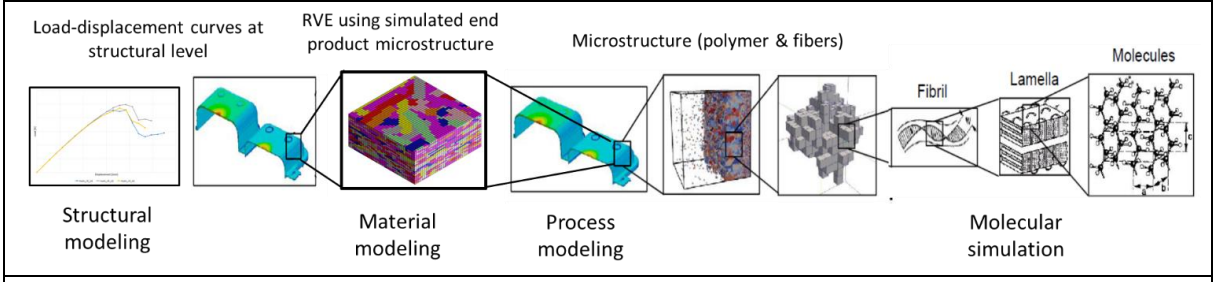

Figure 3: Modeling chain of polymers in DFC.

The scope of the Sandbox scenario is to identify the input and output data that is needed to sufficiently describe the different stages of the modeling chain and state if such data can be derived from virtual experiments, molecular simulation or other methods in the field of integrated computational materials engineering (ICME). In order to bridge the scales homogenization or localization has to be performed. This can obviously lead to a change of numerical methods and thus in the type of discretization.

Particular attention may be paid to:

- Describe how the DFC microstructure (fiber orientation, content, porosity, etc.) can be predicted using process models ?
- How material performances (nonlinear stiffness, strength, viscosity, conductivities, thermal expansion, etc.) can be predicted at the different stages?
- Which engineering quantities are necessary to model each processing step and how can they be derived from microstructural and constituents properties?
- Which features are to be taken into account to fully describe each modeling stage?
- How can homogenization and localization be performed along the modeling chain?
- Are there solutions to handle the data and calculation time throughout the chain (industrial usability versus scientific research)?