A virtual lab framework to determine the anisotropic properties of short fiber reinforced thermoplastics

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S. Zhang, J.A.W. van Dommelen, L.E. Govaert

Background

To predict the yield stress of short fiber reinforced thermoplastics, commonly used in the automotive industry, is of utmost importance in evaluating how the industrial component can withhold before failure occurs. The yield stress is severely influenced by the rate dependent polymer matrix and processing induced fiber orientation. In injection moulded short fiber reinforced thermoplastics, a local spatial variation of the fibers is formed by the processing and leads to anisotropic mechanical behavior. In this work, a micromechanics-based tool to predict the anisotropic properties are utilized for identifying the parameters of micro-macro modelling transition.

Approach

Based on the micromechanical modelling of short fiber reinforced thermoplastics, the anisotropic mechanical properties such as modulus and yield stress are described by the general orthotropic lamina elastic theory and the Hill yield criterion (see Fig. 1).

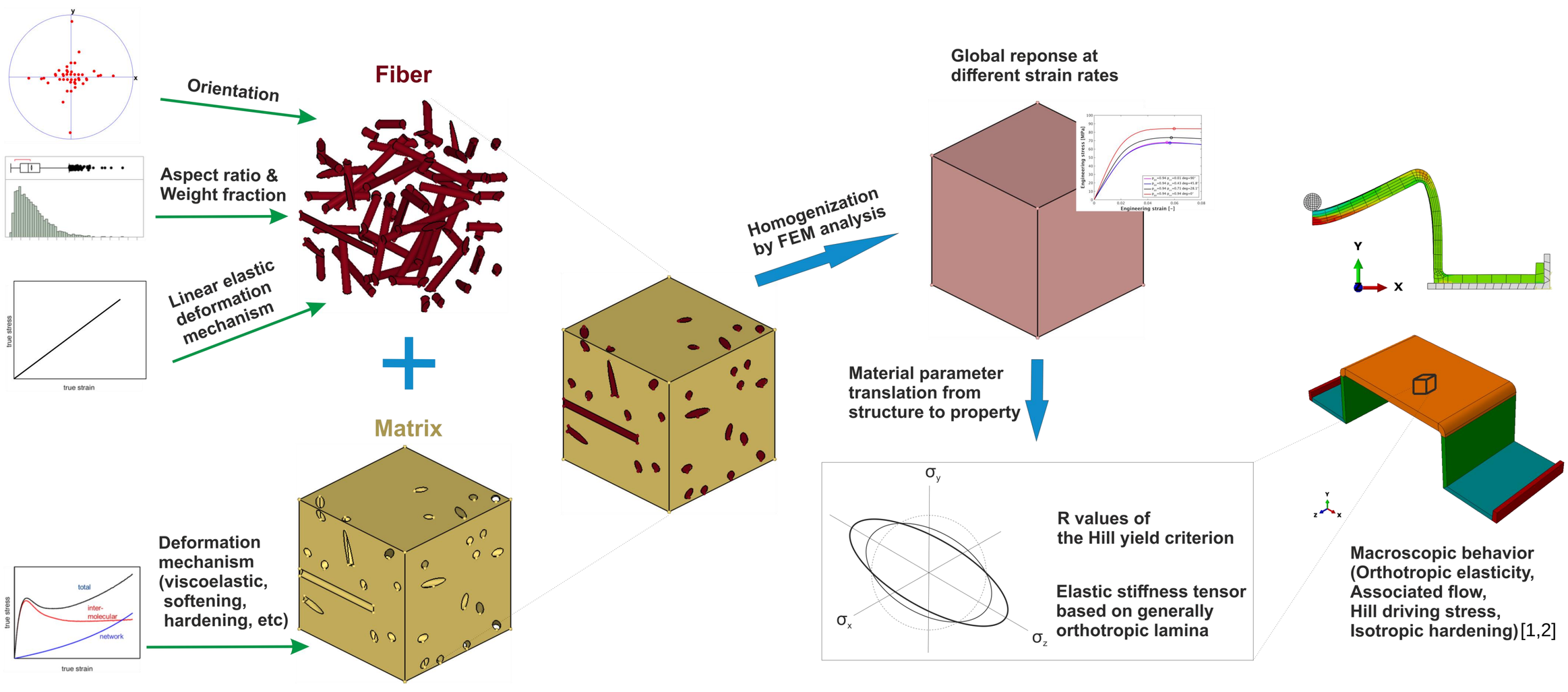

Figure 1: Schematic flow of material parameter transition from micromechanical modelling to macroscopic mechanical performance.

Result and discussion

This micromechanics-based tool can well capture the relation between local material orientation $p_{\sigma\sigma}$ and the anisotropic mechanical properties such as elastic modulus and yield stress (see Fig. 2). This virtual lab framework, using the full field modelling and the parameter identification routines for yield and elastic functions, enables us to combine the advantage of both methods, i.e., the accuracy of the result and the computational efficiency.

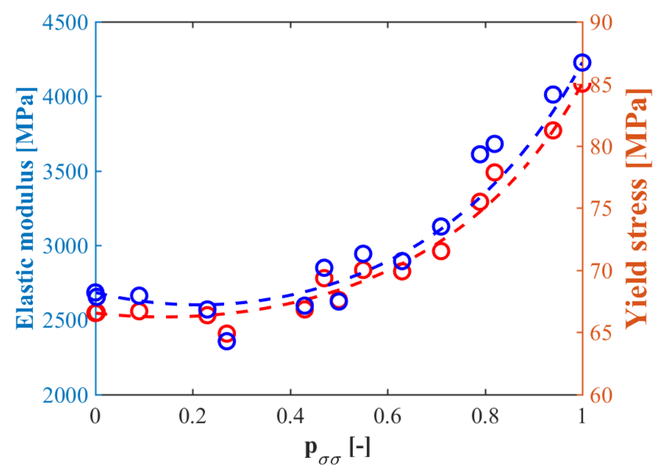

Figure 2: Circles represent the micromechanical modelling results. Dashed line shows the analytical fitting result.

Reference

[1] Amiri-Rad, A., et al. Mechanics of Materials 137 (2019): 103141.

[2] Wismans, M. (2019), Master's thesis, TU Eindhoven.