6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

Large deformation modelling of polymer-based unidirectional and 3D textile-reinforced composites

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Keywords: *large deformations, composites, polymer modelling, textile composites*

Traditionally composite materials are known to show small deformations and as a result are modelled using quasi-brittle modelling approaches. However, a new type of composite materials with finite deforming polymeric constituents and low fibre volume fractions [1] are known to show finite deformations. Therefore, traditional quasi-brittle modelling approaches will not accurately capture their constitutive behaviour. There is need therefore for a new formulation to capture these types of materials. This paper presents a computational framework for modelling finite deforming polymeric composites using typical unidirectional and textile-reinforced composites as a test case. Such composites find applications in areas where damage tolerance properties (resulting from the plastic absorptions associated with finite deformations) are required. We present a case for a polymeric unidirectional composite consisting of polypropylene matrix (of unusually high matrix volume fractions) and a textile composites (where the geometric arrangements and matrix medium contribute to result in finite deformations). A new constitutive model for polypropylene is developed, which accounts for energy dissipations at low and finite. This unidirectional composite has been modelled with the accurate microscale representation of the fibre distribution while the textile composites, has been modelled based on a representative binder architecture. The framework adopts a micromechanical modelling approach (for the unidirectional composites) and a meso-mechanical modelling approach (for the textile composites) [2]. The model predictions have been validated with experiments carried out on a thermoplastic matrix composite (for the unidirectional composite) and an angle-interlock textile composite. Results generated here should help in further model development of these type of composites as well as structural scale designs involving these types of composites that demonstrate large scale deformations and damage-tolerance constraints.

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