Nonuniform Transformation Field Analysis for 3D printed FDM parts

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ABSTRACT

A crucial point in the use of AM solutions for direct production is the modeling of the mechanical behavior of the printed components under real working conditions, so that it can be correctly accounted for during the design phase [1].

The present study focuses on the determination of the mechanical properties of Fused Deposition Modeling (FDM) 3D-printed parts. In FDM processes the material is deposited layer by layer on a printing surface. Each printed layer is made of several thermoplastic polymer filaments which are heated and then extruded; in general, voids are present between filaments, since the deployed material is not able to completely fill the space due to geometrical and process constraints. Accordingly, the obtained media can be considered as a composite with two phases, i.e. filaments and voids.

The aim of the present study is to develop a meso-macro analysis with the goal of studying the mechanical response of FDM 3D-printed material. To this end a representative volume element (RVE) of the heterogeneous material made of filaments and voids is analyzed. Then, a homogenization technique, based on Transformation Field Analysis [2][3], is implemented. The homogenization approach is able to model the nonlinear phenomena occurring at the mesoscale level, introducing an approximation for the inelastic strain field. Thus, a proper constitutive model for the filament, able to describe all the non-linear phenomena occurring in the material, is proposed.

The RVE is divided in subsets through an *optimization-based approach*, and in each subset the inelastic strain is assumed to be *uniform* or *nonuniform*. A numerical procedure is developed to study the evolution of the subsets' inelastic strains, that represent the internal variables of the problem.

In order to assess the efficiency of both the proposed micromechanical approach and the homogenization technique, comparisons with experimental data are performed.

References

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