On the design of mechanical heterogeneous specimens using both parametric and topology optimization

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ABSTRACT

Nowadays, virtual manufacturing tools have gained widespread popularity in the engineering community. Numerical simulation software plays a significant role in the design and development of new mechanical parts. However, the results' reliability is highly dependent on the accuracy of the input data, namely, on the chosen constitutive model, particularly in the case of elastoplasticity. The calibration of constitutive models is usually performed by carrying out standard mechanical tests. However, each test is only able to activate a reduced number of identified parameters due to the homogeneous strain and stress states induced on the specimens. A large number of mechanical tests are then required, consisting in an expensive and time-consuming procedure. Therefore, there is an urgent need to enhance the material characterization process by developing new test configurations capable of providing relevant information to calibrate material models cost-effectively.

This work aims to design a new non-conventional heterogeneous mechanical test by using an innovative approach. A bi-level optimization procedure is proposed to generate optimal specimen designs effective in inducing rich heterogeneous strain fields. The design process is based on a topology optimization methodology with its foundations on the compliant mechanisms' theory [1]. Thus, new material distributions, impossible to achieve with other design methods, are obtained with highly heterogeneous displacement fields. Furthermore, a buckling criterion [2], and a methodology to obtain smooth and clear boundaries [3] are implemented. On top of that, an upper-level optimization problem establishes a parametric study on four specimen characteristics. Therefore, the maximization of a performance indicator [4,5] takes place to evaluate the richness of strain and stress fields generated on the obtained specimens from the design procedure.

This work will provide a methodology to design optimal heterogeneous test configurations. The obtained results will further contribute to an enhanced material characterization process and, consequently, to providing accurate results from virtual manufacturing tools.

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