On the topology design of a mechanical heterogeneous specimen using geometric and material nonlinearities

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Abstract

Material characterization and the calibration of constitutive models are of utmost importance for the majority of the forming processes nowadays. For an accurate virtualization of the development processes, the material mechanical behavior needs to be known a priori. The classical characterization procedure involves carrying out several standard mechanical tests to identify the required information about the material. However, this procedure turns out to be expensive and time-consuming. Heterogeneous mechanical tests have been used to overcome this issue. By providing richer information with a reduced number of tests, their use can enhance the actual material characterization process. This work aims at making a significant contribution towards this goal by designing a heterogeneous mechanical test using topology optimization. A specimen topology is obtained with a heterogeneous displacement field by applying the theory of compliant mechanisms [1]. Due to the large displacements considered, a geometrically nonlinear finite element analysis and topology optimization procedure are proposed [2]. Material nonlinearity is taken into account as well, to design solutions closer to reality [3]. An optimal mechanical test with a highly heterogeneous strain field is obtained and evaluated, considering its diversity, using mechanism theory and a mechanical indicator [1].

References

[1] B. Barroqueiro et al., Design of mechanical heterogeneous specimens using topology optimization, Int. J. Mech. Sci 181 (2020) 105764.
[2] Y. Han et al., An efficient 137-line MATLAB code for geometrically nonlinear topology optimization using bi-directional evolutionary structural optimization method, Struct. Multidiscip. Optim 63 (2021) 2571:2588.
[3] D.M. De Leon et al., Stress-based topology optimization of compliant mechanisms design using geometrical and material nonlinearities, Struct. Multidiscip. Optim 62 (2020) 231-248.