Design of mechanical heterogeneous specimens using topology optimization

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Nowadays, the development and design of new parts require an increasing knowledge of the materials' behaviour. Additionally, for the current sophisticated numerical modeling tools, accurate material characterization is critical for the correct calibration of their constitutive models. The constitutive behaviour of a material can be characterized via macroscopic mechanical tests. However, the full material characterization is expensive due to a large number of required tests. Therefore, there is a need to reduce the number of tests by increasing (quantitatively and qualitatively) the information available on a single test. To this end, heterogeneous strain field specimens can provide an answer. In the scope of this work, an innovative numerical methodology to design heterogeneous specimens using Topology Optimization (TO) is presented, together with its formulation and implementation. Numerous designs are presented and assessed through a performance indicator that evaluates the uniformity of the equivalent stress maps and the presence of various stress states (tension, compression and shear) in the specimen. Finally, the most adequate design is redrawn, analyzed and evaluated in an elastoplasticity framework. Validation of the test is also made by comparison.

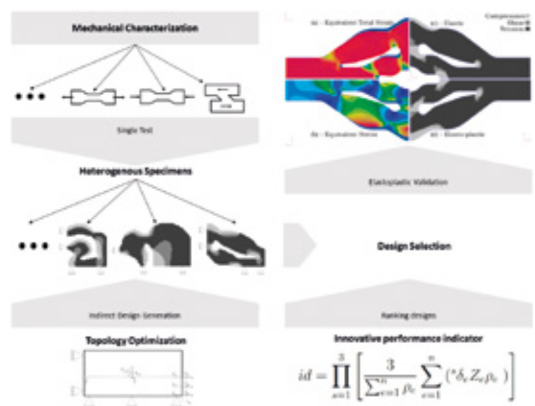

FIGURE 1
A systematic methodology for designing heterogeneous specimens has its foundations on mechanisms synthesis theory, and uses an indicator to estimate their heterogeneity performance. The proposed design, when subject to a tensile loading, is seen to be capable of providing an interesting diversity of stress states when extended to elastoplasticity and is capable replacing several classical mechanical tests to characterize the material's behavior.