Characterization and modeling of mechanical behavior of polymer TPS and TPV reinforced by voids cells

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Abstract

One of the most important strategies to limit carbon emissions and promote a circular economy in the transport sector is the use of recyclable materials [1]. In addition, lightweight structures reduce energy consumption by reducing vehicle mass, improving efficiency, and limiting greenhouse gas emissions. One innovative approach to achieving this objective is the development of a new generation of materials, typically porous materials. These can be designed by inserting rigid void cells within the polymer matrix.

This work investigates the mechanical properties of thermoplastic materials reinforced by void cells and proposes a strategy to model their mechanical behavior. Two different types of thermoplastic have been considered for the polymer matrix: a TPS (Thermoplastic styrene or TPES) and a TPV (thermoplastic rubber vulcanizate). Specimens have been tested under cyclic tensile loadings. Volume changes have been measured during the mechanical tests.

Results show that the mechanical responses obtained exhibit a Mullins effect. It is shown that the stabilized, i.e. demullinized, behavior can be predicted by using hyperelastic models [2, 3] [4, 5]. Volume change measurements under strain revealed that the void cells induce only slight changes in volume of the TPS and TPV matrix by breaking down the hyperelastic behavior into deviatoric (shear) and spherical (compressibility) components [6, 7, 8, 5]. Moreover, the influence of void cells on the mechanical behavior depends on the rate of void cells used and on the matrix miscrostructure, which strongly differ between TPS and TPV. To go further, data issued from Xray tomography (shape, dimensions, volume fraction of void cells) as well as mechanical properties of cells whole and thermoplastic matrix are used to build a digital twin of the material in order to predict the effect of shape, dimensions and volume fraction of void cells on the mechanical reponse.

References

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