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ABSTRACT:

The mechanisms of void nucleation, growth and coalescence for neat and glass syntactic polypropylene using in-situ tensile tests on synchrotron radiation tomography

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Glass syntactic polypropylene (GSPP) is used for thermal insulation of subsea pipelines. Flat notched specimens were used to study the mechanisms of deformation and voiding thanks to in-situ tests conducted at Psiché beamline of Soleil Synchrotron Radiation Facility. High resolution data sets (1px = 1.3 μm) were obtained at each increment of the loading.

The interaction between the matrix and the glass hollow microspheres (GHM) was highlighted using gradually the consecutive images of: i) the neat PP matrix; ii) embedded unique GHM within the PP matrix; iii) the GSPP composite with the real distribution of GHM.

In the PP-matrix void nucleation, growth and coalescence resulted in crazes like microstructures at the deformed states. For the GSPP composite, voids nucleated by the decohesion of the matrix at the poles of GHM. Due to the high GHM volume fraction, these initiated voids were observed to coalesce, either with other surrounding but similar voids, or with the crazes in the matrix. These two kinds of void resulted in a development of a significant irreversible volume change (plastic dilation), related : i) at the macroscopic scale, to the reduction of the width and the thickness; ii) at the microscopic scale, to the local void volume fraction requiring the determination of a relevant representative volume element allowing the spatial and time distributions of the void volume fraction to be plotted.

By using macroscopic data, Finite Element simulations using elasto-visco-plastic porous model were attempted. The inverse optimization of the material parameters was performed with the help of the reduction of width and thickness of the minimal cross section. Then, the distribution of the simulated void volume fraction was compared with that of the measured plastic dilation, leading to a good agreement to the two profiles.