Crash of 3D-braided thermoplastic tubes: numerical and analytical tools for behaviour prediction

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ABSTRACT

Future standards regarding CO2 emissions lead to a major issue for the car manufacturers: the weight of vehicles must be drastically reduced and composite materials appear to be good candidates and especially for some structural parts such as energy absorbers. To be efficient, this piece must absorb the crash energy by deforming and damaging itself in a stable way. Whereas the behaviour of metallic parts is fully understood and predictable, the heterogeneity and the anisotropy of composite materials complicate the problematic and some major enhancements in numerical prediction of composite crashworthiness are needed to allow their diffusion in the industry.

The present work is dedicated to the study of tubes made of an interlock 3D-braided glass fibres/polypropylene composite. Objectives are the creation of analytical and numerical tools in order to efficiently predict the performance and the behaviour of these tubes during a crash.

Experiments have been first realized on a drop-weight tower for different orientations, masses, velocities, impact angles. We were able to determine the role of the composite properties and of the structure into the performances during a crash. A complete characterization of this material was also made in order to provide mechanical properties for the numerical modelling.

On a second step, we have proposed a numerical buckling analysis in order to correlate the experimental observations (modes and triggering strength). Based on it and on the experiments results, we described the kinematic of the crushing tube in an analytical model. We associated the different mechanisms of energy absorption and determined the performance of the material. The aim of this approach and of the modelling is to provide efficient tools as for metallic tubes which allow a quick evaluation of the use of a particular composite material for crash application [2], [3].

In parallel, a more accurate material model has been developed as an Abaqus user material. The model takes into account in tension and compression, elasticity, inelasticity and strain rates sensitivity. Based on the work the LMT Cachan, this model is biphasic and uses the kinking theory for fibres. The matrix behaviour is based on the Drosdov model for thermoplastic resins [1]. Good results have been found for predicting both the mode of crushing and the performance of the tube.

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