Mechanical Properties of Injection-Moulded Automotive Parts

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Numerical simulation of impact loading of polymer materials is of great industrial interest [1-3], as these materials are increasingly being used in critical applications and constructions. The response to impact loads is of particular interest for automotive applications related to pedestrian safety.

Our aim is to improve material models and test methods for numerical simulation of impact loading to predict the mechanical response of automotive components, in which the materials may undergo large multiaxial deformations at high strain rates. Our work focuses on ductile thermoplastics, typically polypropylene compounds containing elastomers and talc [3, 4]. Models used for these materials today have shortcomings when it comes to predicting multiaxial loading, unloading response (rebound), and fracture. The unloading response, in particular, is important when designing parts for a pedestrian protection system, see Fig. 1.

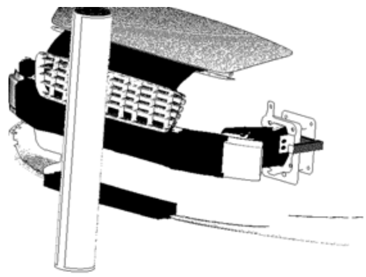

Figure 1. A test for the impact between pedestrian (leg) and car front. Impact speed: 40 km/h (11 m/s).

Based on industrial challenges, our studies aim to improve the numerical simulation of the following low-speed impact cases:

- Unloading response of parts in a pedestrian safety system. Typical impact speed 10 m/s, see illustrative test data in Fig. 2.
- Impact fracture of exterior parts in cold weather. Impact speed for relevant cases: 3-4 m/s.

The anisotropy and inhomogeneity of injection-moulded parts is a challenge when trying to model and simulate their mechanical response at large strains. The ultimate goal is to simulate the mechanical response with local mechanical properties from a simulation of the moulding process.

Our focus is on the materials, the injection moulding process (process-induced effects) and the mechanical testing (polymer-related challenges):

- Materials: Linking mechanical response to microstructure, and features of specific PP grades. Characterization techniques such as microscopy are important for this task.
- Injection moulding process: Effects of processing conditions (illustrated in Fig. 3), specimen thickness, surface roughness etc on mechanical response. This includes effects of inhomogeneity, anisotropy and residual stresses.
- Mechanical testing: For these ductile soft polymers, several tests are challenging, e.g. compression, shear and high-speed tension. In order to obtain reliable true stress-strain data, we seek to optimise and improve the tests, with the help of full-field strain measurements (using digital image correlation) and numerical simulations (LS-DYNA). Inverse modelling will be applied to some tests.

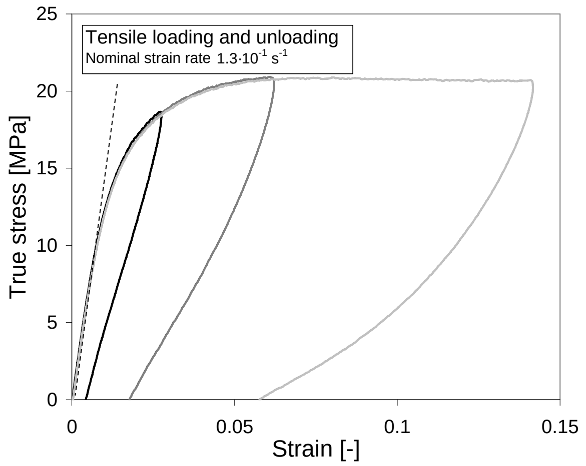

Figure 2. Tensile loading to different strains, followed by unloading at the same rate. Dashed line: Tensile modulus.

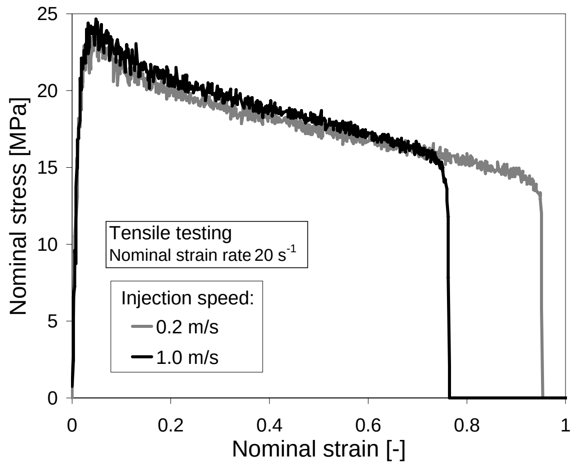

Figure 3. High-speed tensile testing of specimens moulded with two different injection speeds.

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