Objective, challenges and approach

- Objective: Improve material models and material data (input to the models)
- We address experimental challenges, such as non-uniform strain fields and force oscillations
  - Un-field measurements and inverse modeling techniques are employed to deal with non-uniform strain fields
- Low-speed impact cases in our study:
  - Unloading response of parts in a pedestrian safety system at impact speed 10 m/s
  - Impact fracture of exterior parts in cold weather at impact speed 4 m/s
- Our focus is on the polymer materials, mechanical testing (polymer-related challenges), and the moulding process (process-induced effects)
  - Polypropylene materials containing talc and elastomers

Process-induced effects (injection moulding process)

- Inhomogeneity, anisotropy and residual stresses of injection-moulded parts are challenges when trying to model and simulate the mechanical response
- Processing conditions, e.g. the injection speed, affect the mechanical properties
- Geometry parameters, such as part thickness and surface roughness, affect the mechanical properties, in interaction with the moulding process

Impact tests

- Low-temperature low-speed impact – centrally loaded plates
  - Effects of impact speed, temperature, plate thickness, surface roughness, processing etc
- Test specimens for tensile, compressive and shear testing machined from a moulded part (grey), in order to study effects of anisotropy, variation along flow path etc. A gating system with two gates can also be used, creating a weld line.

Compressive tests

- Challenges: Buckling (limiting the max. strain) and barrelling (non-uniform strain)
- Experimental work in progress: Effects of specimen height/width ratio, and friction between specimen and fixture

Sheet tests

- Challenges: Non-uniform strain field and non-shear strain components

Tensile tests (≤ 10 m/s)

- Challenges: Strain localisation (necking) and force oscillations

Unloading response (rebound)

- Unloading response studied by tensile loading/unloading and by instrumented falling weight impact

Conclusion

- There are several challenges involved in obtaining true stress-strain data of ductile polymers for different stress states and large strains
- Mechanical properties of injection-moulded parts may vary from point to point, hence, effects of processing (injection moulding) must be assessed
- Full-field strain measurements and inverse modelling can provide more reliable true stress-strain data for large strains

Introduction

- Numerical simulation of impact loading of polymers is of industrial interest, as polymers are increasingly being used in critical applications, such as automotive components