

New trends and aspects in polymer mechanics

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Polymers are low-priced and popular materials which are indispensable in a large number of technical applications. In order to make serious statements and to provide simulation-based predictions regarding the strength and the durability of polymer products like sealings, adhesive seams, containers or coatings under environmental influences or thermomechanical loadings, comprehensive experimental studies, a deep physical understanding and associated material models are required. Thermosets, elastomers and thermoplastics are more or less cross-linked polymers which exhibit a large set of characteristic phenomena: the glass transition, melting, crystallisation, curing and different kinds of ageing. Since most of these effects depend in a rate-dependent manner on the entire thermomechanical process history it is impossible to develop one single model that can cover all of them. The formulation of constitutive models depends also on the magnitude of the expected deformations or temperatures and their rates or frequencies.

In the presentation, a selection of such phenomena is sketched or experimentally investigated, physically interpreted and constitutively represented. The glass transition, ageing and crystallisation are considered. Since physical ageing and crystallisation are reversible under sufficient high temperatures, constitutive models to represent such effects exhibit special mathematical structures. In order to model irreversible phenomena like chemical ageing or curing the structure of such a model is completely different. To this end, appropriate thermodynamic potential functions are selected, internal variables have to be defined and physically-based evolution equations have to be formulated. For the development of constitutive models for polymers it is necessary to take not only the temperature-dependent mechanical material behaviour into account. Since the consideration of thermomechanical and caloric phenomena is also necessary the specific Helmholtz free energy is not always the best choice. The presentation closes with a short discussion of some future challenges and open questions.

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