Computational Micromechanics Laboratory

Fall 2021 Seminar Series #01

A Physically Grounded Approach for Shear Yielding and Crazing Induced Fracture in Amorphous Polymers

Osman Gültekin, PhD

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ABSTRACT

Amorphous glassy polymers such as polystyrene (PS) are subject to shear yielding under low strain-rate, relatively high temperature levels and high entanglement density. This ductile mechanical response changes into a brittle response, particularly in polymethymethacrylate (PMMA), due to the development of crazes favored by high strain-rate, relatively low temperature levels, and low entanglement density under tension dominated straining due the existence of flaws or grooves in the material. The well-accepted double-kink theory explains the volume-preserving shear yielding response of the polymers, while the craze growth is well explained by the interface convolution mechanism, i.e. the meniscus instability, induced by volumetric inelastic deformations. This study presents a physically grounded thermomechanical approach to model shear yielding and crazing simultaneously. The multi-field problem is numerically treated in the finite element context based on the efficient operator splitting algorithm. Finally, the numerical performance of the model is demonstrated through benchmark boundary value problems regarding the onset and growth of plastic and crazing strains inducing the ultimate rupture in the material.

BIOGRAPHY

Osman Gültekin holds a Bachelor's degree from the Department of Civil Engineering at Middle East Technical University in Ankara. Upon completing his Bachelor's study in 2011, Dr. Gültekin moved to Stuttgart, Germany and enrolled in the international Master's degree program, Computational Mechanics of Materials and Structures (COMMAS) at University of Stuttgart where he performed the Master's thesis study under the supervision of Assoc. Prof. Dr. Hüsnü Dal and late Prof. Dr. Christian Miehe. He received his M.Sc. degree in 2014 with the thesis entitled "A Phase-Field Approach to the Fracture of Anisotropic Medium". In February 2014, Osman started his doctoral studies at the Institute of Biomechanics, Graz University of Technology (TU Graz) under the supervision of Prof. Dr. Gerhard A. Holzapfel. His research was largely focused on the better understanding of the mechanics of soft biological tissues, in particular the myocardium and arterial walls in health and disease based on the computational methods. He completed his Ph.D. study with distinction in November 2018 with the thesis entitled "Computational Inelasticity of Fibrous Biological Tissues with a Focus on Viscoelasticity, Damage and Rupture".