Experimental investigation and continuum mechanical modelling of size effects in polymer layers

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During the last decades glueing became a popular joining technology especially in light weight construction. In order to allow for an appropriate description of glued components in simulations the behaviour of polymer layers hast to be investigated experimentally and theoretically.
In this presentation the mechanical behaviour of polyurethan layers is studied in shear experiments. As expected, it is found that the polymer behaves viscoelastic. Furthermore, if the layer thickness is varied, the experiments show a strong size effect, i. e. the effective stiffness of the specimen depends on the layer thickness. In contrast to the size effects documented in literature thin layers behave weaker than thick layers. From the physical point of view the formation of interphases between the polymer and the substrate is responsible for this behaviour.
In a first part of the presentation the experimental setup of classical tension tests and of the above mentioned shear tests is discussed. The experimental results are presented for different loading rates showing viscoelastic effects. In order to minimize the experiments isothermal conditions are applied.
Based on the results of the tension tests the concepts of viscoelasticity are motivated starting from a simple rheological model. The model consists of a spring (Hooke element) and a spring-dashpot combination (Maxwell element). This model is able to describe the essential properties of viscoelastic materials, i. e. kreep and relaxation can be captured in an appropriate way. In a second step the model is extended towards a threedimensional continuum mechanical model taking into account finite viscoelasticity. It is shown how the ideas of the rheological model are transfered to the finite model. For the presented model the thermodynamical consistency is shown.
A model formulated in the framework of classical continuum mechanics is not able to predict size effects. Therefore, an extension of the classical approach is motivated. An additional structural parameter is introduced which describes the local variation of the material properties in the polymer layer.
Combining this extension with the concepts of finite viscoelasticity yields an extended model which is able to describe the experimentally observed effects. An appropriate strategy for the parameter identification is proposed and it is shown that the involved model parameters can be quantified based on the experimental results.