TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Public summary of the PhD-thesis of Coen Clarijs
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Understanding and predicting break down of polymers

Utensils, water bottles, clothing, consumer electronics. Polymers, usually called plastics, are found everywhere in daily life. The demands on mechanical properties may be relatively low in case of these relatively simple products. However, polymers are also widely used in load-bearing, structural engineering applications and for these structural engineering applications the demands on mechanical strength and resilience can be stringent. PhD-research of mechanical engineer Coen Clarijs provides more understanding and prediction of polymer break down.

An example of a demanding structural engineering application, using high-performance polymers, is the Solar Impulse 2 airplane. This airplane finished a flight around the world in 2016, benefiting from the many polymers that were used because of their versatility, easy processing and low weight, high specific strength and stiffness. Polymers that are used in structural engineering applications usually have a desired service life time in the order of decades. However, the service life of such components is generally limited by the polymer's time-dependent behavior, which will ultimately lead to catastrophic breakdown under any condition. It is evident that being able to understand and predict when and how breakdown of these polymer parts will occur, and ultimately, preventing breakdown to occur within the life time of a product, is of utmost importance.

The goal of my PhD project is to give more insight in polymer breakdown, and how the performance correlates with molecular structure. To do so, computer simulations combined with various laboratory experiments were used to investigate polymer breakdown, as well as attempting to predict when breakdown will occur under specific circumstances.

With a dedicated constitutive model polymer breakdown in both short and long-term loading conditions could be predicted. Regarding short-term breakdown under impact conditions, the time at which a transition from preferred ductile break down to unwanted brittle breakdown occurs could be accurately predicted. For long-term breakdown the influence of progressive physical ageing cannot be neglected. Taking this phenomenon into account leads to improved and accurate predictions of the breakdown time under prolonged loading, both for static as well as cyclic conditions.

Besides being able to predict breakdown under different circumstances, the use of three different polymers - more specific polysulfones - with similar backbone structure, enabled investigation of the relation between the molecular structure of a polymer and its mechanical properties. It appears that many mechanical properties correlate with the network density of the polymer: in general a higher network density gives better mechanical properties.

The results obtained contribute to a better understanding of polymer breakdown, which aids the design of polymer products. Furthermore, the obtained structure-property relations may serve as guide-lines for the development of materials with improved properties, like for example improved resistance against cavitation under impact conditions.

Title of PhD-thesis: Mechanical performance of glassy polymers: Influence of physical ageing and molecular architecture. Supervisors: Leon E. Govaert (TU/e), Patrick D. Anderson (TU/e). Other main parties involved: Solvay Specialty Polymers (Alpharetta, USA).