Polymer Services Group
Innovation, Application, Evaluation

The Fallacy of Tensile Strength

One of the most-often-specified properties for polymers, and indeed for most materials, is tensile strength. It is used in comparisons of materials to determine which material is the "strongest" --- i.e., which material is most likely to succeed in an application. Unfortunately, many times a material is specified based primarily on its higher tensile strength without a fair understanding of what that number represents or how it was developed.

"Tensile strength", as the term is used in more traditional materials like metals, ceramics, glass, etc., is synonymous with the breaking strength of the material. It is the ultimate strength, above which the material fails; and if that load is never achieved --- failure does not occur.

Polymers, however, are rate-, temperature-, and environmentally sensitive. Although, there has been considerable standardization of testing variables which allows consistent comparison of tensile strength between similar materials, different materials may measure the tensile properties using different crosshead speeds or different specimen geometries, which vary the actual strain rates under which the tensile properties are determined --- sometimes by more than a factor of 100. Therefore, a clean-cut "by the numbers" comparison between different materials may not be achievable, or is very difficult at best.

Values reported as "tensile strength" can be either the tensile yield strength or the tensile break strength --- usually the higher of the two is reported. In some high elongation polymers, strain hardening can result in a higher break strength than its yield strength, but this strength is only achieved after significant deformation has occurred --- not a very good design criterion. In other cases technicians will report a higher break strength than yield in situations where the material begins to neck-down into the shoulder of the test specimen --- a purely fictitious number given the higher cross sectional area of shoulder of the specimen. Other materials don't exhibit a true yield point and only the break strength is reported --- well after the material has deviated from a proportional stress-strain behavior and significant stretching and deformation has taken place.

Even with the same material the tensile behavior of a material can vary from strong (high tensile strength), rigid (high modulus), and brittle (low elongation) to soft, rubbery, highly extensible material just by varying the strain rate conditions. As an example, the creep-rupture strength of most polymers (the ultimately slow tensile test) is generally 20 to 30% of the short-term tensile strength as measured in a typical tensile test. So by varying only the speed of deformation, the actual tensile strength of a material can vary all over the map --- without even considering the effects of temperature and environment.

The moral of the story: **Don't judge a material by its numbers** --- there isn't just one tensile strength for a polymeric material and for the most part those strengths that are reported for different materials may not be comparable. Understand how each material behaves under different conditions and environments --- and keep in mind how it will have to ultimately perform in its actual application. Judge each material on its own merits, and design the part based on your best understanding of the mechanical behavior of the candidate material and the conditions of the application.

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