Environmental stress cracking – bend strip test

Initial remarks

The mechanical load-bearing capacity of plastics that are in contact with chemicals can only be assessed correctly if knowledge is available on the additional effect that mechanical tensile stress has on the behaviour of the plastics vis-à-vis chemicals. Tensile stresses expand the structure of the materials and thereby generally reduce their resistance to environmental influences.

The behaviour of a material vis-à-vis chemicals under the action of tensile stress can be checked in a tensile creep test or flexural creep test in which the specimen surface is additionally exposed to solid, liquid and gaseous media. In the case of tests that are to be conducted on a large scale, these methods are generally only applied for plastics which display a high level of relaxation (primarily semi-crystalline plastics) on account of the large outlay on apparatus that is involved. Amorphous plastics can usually be tested by the bending strip method, since they generally have a low relaxation tendency.

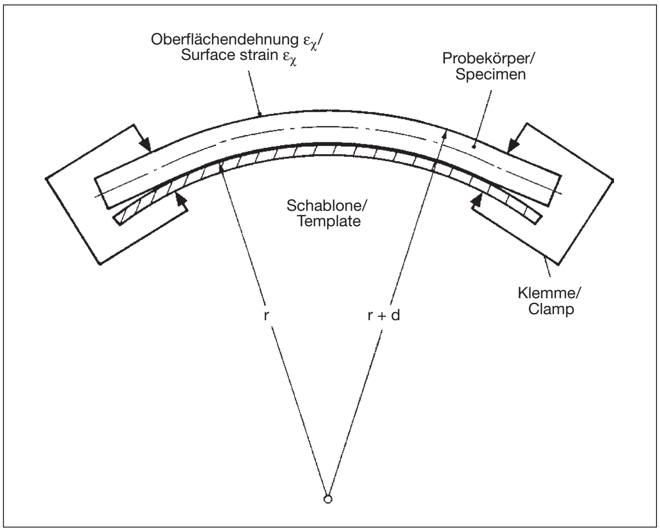

Fig. 1: Bending strips with a defined surface strain

Underlying principle of the test method

Test specimens are held in an arc shape, by means of two clamps, on the surface of a template in chemical-resistant material, with a radius of curvature r. This leads to a surface strain of $\varepsilon_\chi \approx d/(2r + d)$ in the tensile zone of the specimen, Fig. 1.

By employing different radii of curvature for the templates and/or different specimen thicknesses, it is possible to vary the surface strain in small increments (pre-strain stages).

Stress cracks are frequently taken as an indicator of damage having occurred. Since these cracks are not always clearly visible, it is a good idea to conduct an objective assessment on the basis of a change in an appropriate property ("indicator property") by a specified amount ("criterion").

The damage strain is the surface strain that leads to fulfilment of the criterion. This is a function not only of the environment but also of the state of the specimen and the temperature.

Method

The specimens that have been clamped on the templates are brought into contact with the test medium either over their entirety or simply in the tensile zone for an agreed period of time at the testing temperature. Agents with a low volatility should be applied, drop by drop, to strips of non-woven fabric-type paper which are then placed on the specimen. Paste-like substances should be brushed on to firm materials, such as elastomer specimens, or pieces of plastic containing plasticiser should be placed on top of the specimen and, where appropriate, fixed in place by a second specimen (sandwich), Fig. 2.

After storage, the specimens are first subjected to a visual inspection. Following this, properties that display a sensitive reaction to damage (e.g. elongation at break and impact strength) are established on the specimens, subsequent to load removal, in the short-time test. The impact strength according to Charpy on a flat rod of dimensions 80 x 10 x 4 mm has proved to be an appropriate property for the amorphous plastics of Apec®, Bayblend® and Makrolon®.
In order to "develop" the damage that has taken place, thermal treatment should be carried out beforehand and/or the impact strength established at a low temperature.

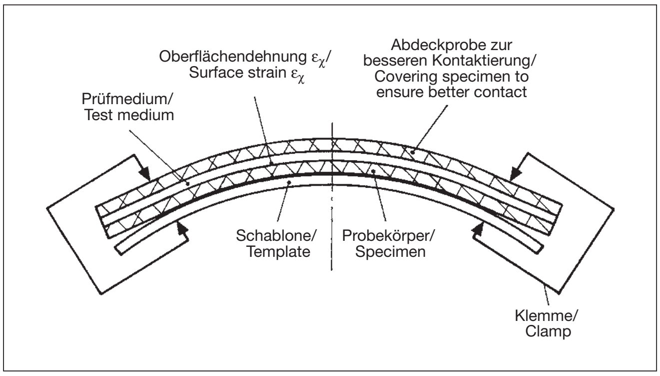

Fig. 2: Example of the clamping configuration for a test medium in solid form (sandwich)

Evaluation of the test

The property value studied is plotted over the surface strain $^{\varepsilon}\chi$ that was applied. In the event of material damage, the property curve will generally display a stepped shape, Fig. 3. The surface strain that is allocated to the sharp drop is the required damage strain $^{\varepsilon}$GP in the test medium or $^{\varepsilon}$GV in the comparative medium.

The ratio of the damage strain in the medium and the comparative medium (usually air)

$$\frac{^{\varepsilon}GP}{^{\varepsilon}GV}$$

indicates the extent to which the level of strain that can still be regarded as permissible in the comparative medium is reduced through the action of the medium.

The first stress cracks generally also occur in the region of the sharp drop. After a sufficiently long exposure time (1 to 3 weeks, as a function of the plastic and the temperature) no essential change is to be expected in the damage strain $^{\varepsilon}$G with continued exposure to the surrounding medium. This means, therefore, that the damage strain can be regarded as time-independent variable.

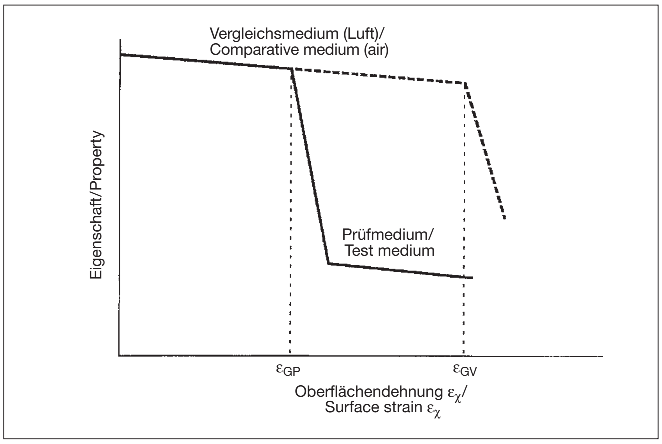

Fig. 3: Property curves and damage strains $^{\varepsilon}$GV

covestro

Covestro Deutschland AG
Business Unit Polycarbonates
D-51365 Leverkusen

plastics@covestro.com
www.plastics.covestro.com