BRITTLE FAILURE OF TOUGH POLYMERS AFTER AGING

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Physical-chemical changes of polymers and composite materials under the influence of atmospheric aging are often limited by the near-surface area of several microns up to tenths of millimeters, as shown by Buckhall (1). Quasi-static axial tensile tests on plastics and polycarbonates performed in the operating temperature range of 213-333 K applied especially for cold climate, have shown sharp worsening of strain and strength characteristics. As for ABC plastic, for instance, strength had decreased to one third of the original value during one month of exposition. The results are suggested to be interpreted from the point of view of fracture mechanics considering a two-layer model: a brittle surface layaer acting as a crack initiating material reflecting the peculiarities of the aged material. The surface layer being tested on dilatation is initiating brittle fracture; the role of the base material is to resist to the crack propagation. Based on data of fractographic analysis of the fracture surface it is concluded that there is a possibility to interpret the observed brittle-tough transition of the examined specimens by linear fracture mechanics (Curve 3), i.e. an attempt is made to explain this transition by the change of plane strain into plane stress within the plastic zone near the crack front. On the left side of the transition (at lower temperatures) a single cracking of the surface layer is observed followed by a complete destruction of the specimen as a result of unstable crack growth. Multiple cracking of the surface layer is observed at the right side (at higher temperatures). It results a complete destruction of the specimen. At further temperature increase, the specimen is getting practically insensitive to surface cracking and between the limits of the precision of the experiments does not show any further crack propagation. Strength of notched specimens (Curve 2) shows that brittle-tough transition have been observed also on the original material. A shift of this transition temperature towards higher temperatures in connection with a long period of exposition (Curve 3) is explained by a strong increase of the strain rate at the end of the cracks initiated by the surface layer. Analogously to the investigations on metals, one can

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introduce the concept of the transition temperature T_{xp} as a temperature corresponding to a definite dimension of a zone of nonlinear behaviour (plastic zone) regarding a characteristic dimension of the specimen (its thickness) at the moment of fracture and this can serve as a temperature limit of the applicability of linear fracture mechanics.

Data given on Curve 4 shows that the shift of the critical value T_{xp} can be explained by model experiments performed on the original specimens with artificially coated brittle surface layer.

Similar changes of strength values have been observed for series of polystyrene impact plastics and for polycarbonates. During two years of exposition the transition temperature for polycarbonates have been changed from the initial value of 243 K up to 333 K.

More detailed information is presented in the work of Babenko et al.(2). According to the opinion of the authors this investigation can be used as a basis for the development of model presentations proposed by Rolland and Broutman (3).

REFERENCES

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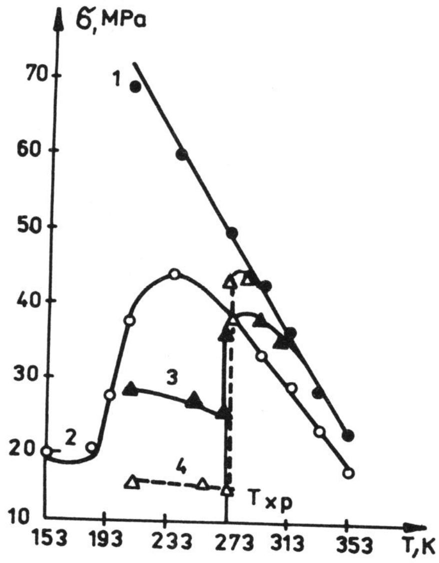

Figure 1 - Strength temperature dependances of ABC-plastic specimen: 1 - initial; 2 - initial with notch; 3 - after three month of exposition; 4 - model with brittle layer.