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Issue Article

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DEFORMATION OF PARTICULATELY FILLED EPOXY POLYMERS

Abstract: *The effect of temperature on the deformation properties of particulate-filled epoxy polymers has been studied. The dependence of the change in the deformation of the samples before the transition to the highly elastic state and in the highly elastic state on the composition of the polymer composite material based on an epoxy binder has been established. The dependence of the rate of reversible deformation on the type and content of the filler in the epoxy polymer is analyzed.*

Key words: *Epoxy-diane resins, dispersed fillers, properties, thermomechanical properties, thermomechanical curve, highly elastic state, reversible deformation.*

Language: *English*

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Introduction

Polymer composite materials (PCM) based on epoxy resins (ES) have high strength, hardness, light resistance, they are distinguished by good thermal and dielectric properties. Mixtures of liquid resins with hardeners form low-viscosity systems, which makes it possible to obtain parts of complex shape. ES cures easily and at virtually any temperature, depending on the type of hardener. The high adhesive ability of epoxy oligomers makes it possible to obtain PCMs with different types of fillers [1–3].

A wide variety of fillers makes it possible to control elastic-strength, electrical, tribotechnical, thermomechanical, deformation, and other properties of composite materials based on epoxy oligomers over a wide range [4–7].

We used epoxy dian resin brand ED–20 (GOST 10587-84), hardener polyethylenepolyamine (PEPA) (TU 2413-646-11131395-2007), which were introduced in a stoichiometric ratio. On fig. 1 shows the topological structure of the resulting epoxy polymer (EP).

To obtain filled (PCM) based on an epoxy binder, dispersed fillers were used microcalcite grade MK-10 (TU 5743-001-91892010-2011), graphite grade GL-1 (GOST 5279-74), molybdenum disulfide grade DMI-7 (TU 48 -19-133-90). The volume content of the filler was 5, 10, 20, 30 or 40 percent of the total volume of the composition.

The study of the effect of temperature on the deformation properties of a particulate-filled epoxy polymer was carried out on a Heppler consistometer. The samples were heated at a rate of 2 K/min, creating a constant compressive stress of 0.32 MPa. The correct choice of load makes it possible to capture the deformation of the sample and its restoration during one experiment. At a low load, at the initial stage of the test, when the EP is in a glassy state, its thermal expansion can exceed the initial compressive strain (Fig. 2. section a-b). In this case, the value of the softening temperature (Tp) in the section a-b determines the change in the type of deformation from expansion to compression [9-11].

With an increase in the applied force, the temperature of thermomechanical destruction (Tmd) decreases. At the optimum mechanical compressive stress, the force applied to the sample compensates for its thermal expansion and the deformation is restored at temperatures above the transition temperature of the sample to the highly elastic state (Twe) (Fig. 2. section c-d) [12-14].

Based on the results of thermomechanical studies, thermomechanical curves (TMC) were constructed in the temperature–strain coordinates.

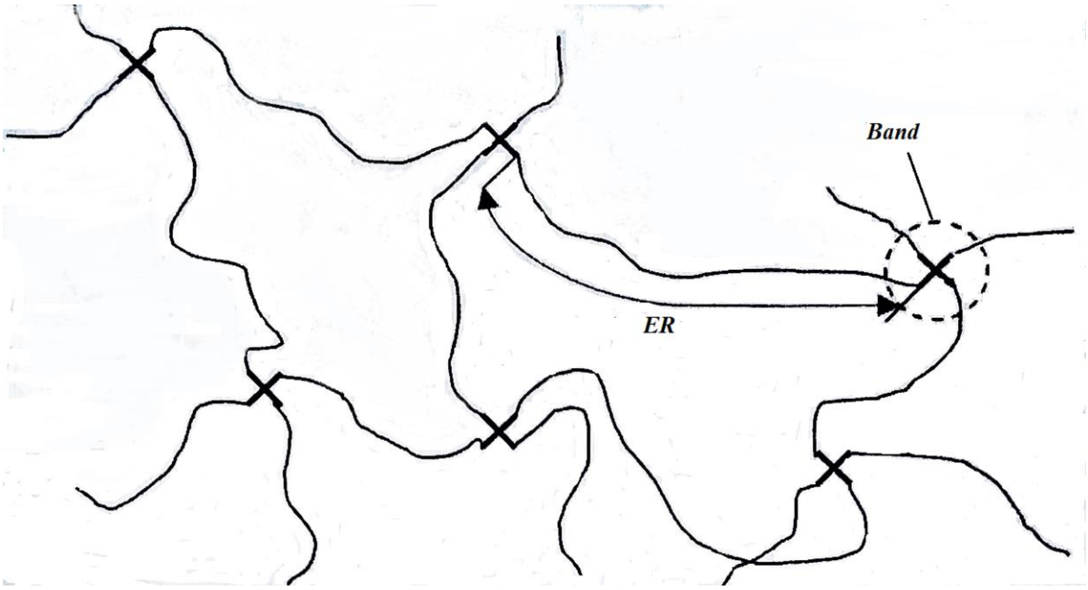

Figure 1. Scheme of the topological structure of the epoxy polymer: ES is a fragment of the spatial network of the epoxy resin. A node is a fragment of a hardener molecule connecting oligomers with terminal functional groups [8].

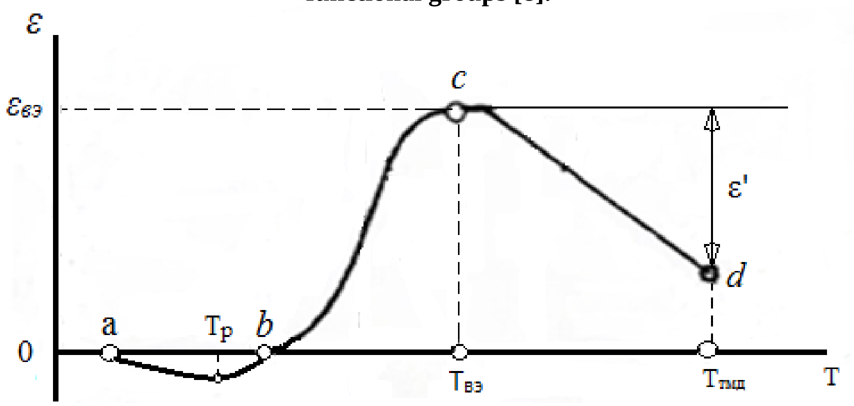

Figure 2. Typical thermomechanical curve of a highly reticulated polymer. ε - deformation (0.01mm); ε' – reverse strain; T is temperature (°C) [15].

According to the TMC data of the samples, the dependence of the deformation of the EP on the content of the filler in it was established (Fig. 3). From fig. 3 shows that with increasing filler content, the deformation decreases. Depending on the type of filler introduced into the EP, with the same filler content, PCMs are deformed in different ways. EP samples filled with molybdenum disulfide (curve 3) are less deformed than samples filled with microcalcite (curve 2) and graphite (curve 1).

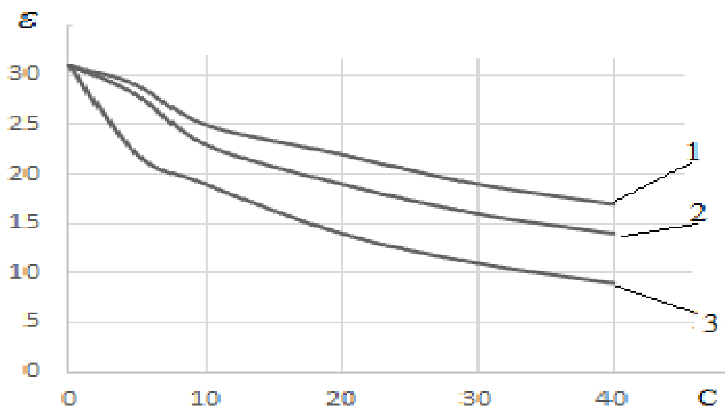

Figure 3. Dependence of deformation of PCM samples ε on the volume content of filler C (%). Fillers: 1 - graphite; 2 - microcalcite; 3 - molybdenum disulfide.

The correct choice of the load made it possible to observe the reversible deformation of all specimens at temperatures above Twe. Changes in the amount and type of filler in the composition of the PCM significantly affected the rate of restoration of the deformation of the samples in the highly elastic state. With an increase in the filler content, the reversible deformation slowed down, and the value of ε' decreased. Moreover, for PCM samples containing more than 20% graphite, reversible deformation occurs more slowly than for PCM with microcalcite and molybdenum disulfide with the same volume content of filler.

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