COMPLEX EVALUATION OF THE THERMOSTABILITY OF AROMATIC FIBRES

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The change in the mechanical properties of the aromatic fibres Armos, Arimid-T, and Togilen in heat treatment was investigated. The change in the strain properties was examined in detail for the first time: the strain modulus and strain energy causing breakage of the fibres during thermochemical aging. It was shown that the intensity of thermochemical aging, estimated by the relative change in the strength and elongation, and strain energy to break differed significantly and should be taken into consideration as a function of the conditions of use of the fibres. Of all fibres investigated, the smallest relative change in the mechanical properties was observed in Arimid-T fibre, and the most important change was observed in Armos and SHM (synthetic high-polymer material) fibres.

In using aromatic fibres and materials based on them, both their deformation–strength properties at ordinary temperatures and the preservation of these characteristics in thermochemical aging caused by high temperatures (250-350°C), i.e., the thermostability, are important. The thermostability is determined by the occurrence of changes in the structure, which are a function of the duration of exposure to the temperature, the presence of impurities (moisture, for example), composition of the medium, and other factors [1].

The fundamental properties of different kinds of aromatic fibre have been described in many studies [1-7]. However, some data on the change in their mechanical properties during thermochemical aging are only reported in a few publications [1, 8-10]. They only contain information on the change in the strength as a result of heating in air in currently widely used conditions: 300°C and 100 h holding time. This approach does not allow sufficiently completely evaluating and determining the difference in the thermostability of aromatic fibres. To determine the thermostability of fibres more complete, it is necessary to study other mechanical properties as a function of the duration of thermochemical aging, since there is no published information on the kinetics of the change in the strength and there is also no evaluation of the thermostability based on the change in the strain characteristics of the fibres: the elongation at break which affects the workability of the fibres and the strain modulus.

Due to the above, we investigated the change in the strength and strain properties of aromatic fibres during different thermochemical aging times: Armos, SHM (synthetic high-polymer material), and Togilen fibres fabricated from polyamide–benzimidazole (PABI) and Arimid-T fibre prepared from polyamide PM.

The mechanical tests were conducted with a FPZ-10/1 tensile testing machine. The breaking load and elongation at break of the initial and heat-treated fibres were determined with the standard method (GOST 6611.2-73) with a clamp length of 500 mm in standard conditions: relative humidity of 65 ± 2% and temperature of 20 ± 2°C. The sample number, equal to 25, ensured obtaining test results with a confidence coefficient of 0.95. The initial strain modulus was calculated with the load–elongation diagrams with relative elongation of 1%. The acoustic modulus of elasticity was determined with the rate of propagation of an elastic pulse for a sample length of 100 mm and a frequency of 100 kHz on the setup described in [11]. The fibres were treated with heat on a rigid frame (perforated spool) at 300°C in air with exposures of 10, 50, 100, 150, 200, 250, and 300 h.

The physicomechanical properties of the initial fibres are reported in Table 1, which shows that these aromatic fibres include two groups with different properties. The first group contained ultrastrong, ultrahigh-modulus Armos and SHM fibres, and the second group consisted of thermostable Arimid-T and Togilen fibres with moderate mechanical properties.

The data on the change in the mechanical properties of these fibres with a different duration of heat treatment are reported in Tables 2 and 3 and in Figs. 1-3. These data show that the character of the change in the mechanical properties of these fibres differs significantly.

In the initial period of heat treatment of Armos and SHM fibres, their strength and elongation decrease significantly. After 50 h of thermochemical aging, they lose more than 50% of their strength. After exposure for 300 h, these fibres retain a total of 7-8% of the initial strength. The elongation at break of these fibres decreases similarly with an increase in the duration of the heat effect. In analyzing Figs. 1 and 2, we can see the close agreement of the characteristics of loss of strength and elongation during thermochemical degradation both for Armos fibre and for SHM fibre. In addition, these fibres become rigid, brittle, and break easily (the elongation at break becomes less than 1% after heat treatments) after 100-150 h of heat treatment at 300°C.