QUALITY NEEDS CONSTANT ATTENTION

WORKING LIFE OF GLASS TUBE SHELLS

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Glass tubes fitted with protective shells are more resistant to internal pressure and shock loading than are unprotected ones and are increasingly used as pipelines in industry instead of ones made of stainless steel or nonferrous metals. Such tubes are currently used at more than 100 organizations, and at some of them, over 20 km of pipe has been installed. The production volume for these glass tubes having thermoplastic jackets has been raised to 150 km a year, and experience has been accumulated in installing and operating them.

It is necessary to provide a long working life in designing pipes for new technologies; the most important elements are the connectors and the protective shells.

The shell is formed under tension, which produces tensile stresses in it [1], and the stresses in the directions shown in Fig. 1 have been estimated by means of a sectional dynamometer and a thermomechanical method based on a UIP-70-M instrument. In the first, one estimates the residual elastic strains, which are then converted to stresses in the circumferential direction, while in the second, one estimates the residual frozen strains in sectional specimens for all directions shown in Fig. 1.

The C-C dynamometer measurements are given in Fig. 2. The elastic stresses are dependent on the thickness, with values in the range 6-20% of the tensile strength, which can be considered as safe. At such stresses, the working life of the shell may be decades [2] (by analogy with glass and plastic tubes). Research confirms this: after test for 11 years on glass tubes with polyethylene shells in a closed building with an air temperature of 15-35°C at 0.5 MPa, no failure was found in the sheaths.

Figure 3 gives frozen strains in three dimensions in high-pressure polyethylene sheaths, as the material is now used in making glass tubes with protective shells.

Fig. 1

Fig. 2

Fig. 1. Major directions of action for residual stresses in a glass tube sheath: C-C) circumferential, L-L) longitudinal, R-R) radial.

Fig. 2. Internal stresses $\sigma$ as a function of sheath thickness $\delta$ for thermoplastic materials: 1 and 2) high-pressure and low-pressure polyethylene correspondingly; 3) polypropylene.

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Fig. 3. Thermal deformations $\Delta h$ in specimens cut from polyethylene sheaths as cubes with 4 mm edges: 1 and 1') circumferential direction; 2 and 2') longitudinal; 3 and 3') radial; 1-3) first heating in dilatometer; 1'-3') second heating in dilatometer, temperature range 0-90°C.

The specimens shrank by 70-100 μm in the circumferential and longitudinal directions on the first heating, while they expanded in the radial direction by about the same amount. There was a notable regularity in the transforming deformations in the local volumes.

Figure 3 indicates marked anisotropy in the thermal expansion: the specific thermal deformations in the longitudinal and circumferential directions are less by factors of 1.5-1.6 than in the radial one. If these frozen strains are converted to possible tensile stresses, one gets on average 3-5 MPa, i.e., approximately as for the elastic strains in the sheaths. The total tensile stresses in the sheaths constitute about half the tensile strength (about 15 MPa).

The stresses influence the strength when there are external factors considerably [3, 4]. The working life is much reduced in the open air with direct exposure to sunlight. This has been confirmed in tests on such tubes in the open air. Surface cracks arise in the sheath within 1.5-2 years, after which they grow rapidly into major cracks (in 6 months to a year).

It is therefore recommended that such pipes in the open air should be protected from direct sunlight. The atmospheric resistance can be raised in direct sunlight by the use of polyethylene stabilized with carbon black. Process conditions in industry [5] have led to the use of atmospherically resistant polyethylene.

Tests on tubes sheathed with that polyethylene have shown that the working life is extended by almost a factor three by comparison with tubes sheathed in high-pressure polyethylene; the working life with the resistant polyethylene is not less than five years.

Glass tubes with such sheaths can be used in various climatic zones.

LITERATURE CITED