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Technical Report

Effect of alkaline and acidic solutions on the tensile properties of glass–polyester pipes

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ABSTRACT

The influence of liquids on the state of stresses and tensile strengths in the longitudinal and circumferential direction of glass–polyester pipes is the subject of this paper. The pipes were manufactured in Corporation "Poliester" Priboj, and had a definite structure and known fabrication process. These analyses are of great importance for the use of glass–polyester pipes in the chemical industry.

The tensile properties were tested and determined for specimens cut out of the pipes; flat specimens for the tensile properties in the longitudinal direction and ring specimens for the tensile properties in the circumferential direction. First, the tension test was performed on virgin samples (without the influence of any liquid), to obtain knowledge about the original tensile properties of the studied composite material. Subsequently, the samples were treated by water, as well as alkaline and acidic solutions: sodium hydroxide (strong alkali), ammonium hydroxide (weak alkali), phosphoric acid (weak acid) and nitric acid (strong acid). The solutions were selected because of considerable differences in their pH values. The pipe segments were exposed to each liquid for 3, 10, 30 and 60 days, at room temperature. Then the specimens cut from these segments were subjected to tension testing by the standard procedure. A comparison of the results was made based on the pH values of the aggressive media in which the examined material had been soaked, as well as based on the original tensile properties and the number of days of treatment. Micromechanical analyses of specimen breakage helped in the elucidation of the influence of the liquids on the structure of the composite pipe and enabled models and mechanisms that produced the change of strength to be proposed.

1. Introduction

The intensive development of polymer engineering, as well as the capabilities of polymers in combination with other materials to form new, synthetic structures of improved mechanical properties, has led to a real expansion in the employment of composite materials, which was followed by a continuous improvement of the technology of their manufacture and usage. Composite materials have a wide range of applications thanks to their good properties under loading conditions, specific mechanisms of crack initiation and growth and capabilities for the accumulation of energy, and represent the greatest competitors to classical construction materials. Their advantages lie in their relatively small mass, good strength/mass and stiffness/mass balances, good static and dynamic properties, good resistance to corrosion, simplified fabrication and short mounting time.

All the stated advantages led to composite pipes being very much used today in the chemical industry, building, infrastructure and war techniques. An important application of pipes made of composites glass fibres – polyester resin is in chemical industry. Pipes made for this use are in exploitation under the influence of static and dynamic loads. Considering the conditions of possible exploitation in the chemical industry, the subjects of this study were prediction of the useful life of glass–polyester composite pipes and determination of the influence of fluids transported through such pipes on their tensile properties in the longitudinal and circumferential directions.

The different structures of composite pipes result in differences in stress and strain fields, which can cause different development of failure after the initiation of the first cracks. In the last few decades, many researchers have considered these points. Special attention was always given to the determination of the stress conditions in the longitudinal and circumferential directions. The best results for pipes have been obtained by the radial-cut method and the ring test. The radial-cut method is a simple, inexpensive and approximate method for determining the residual stress state in a cylindrical part. In this method, the ring is cut in the radial direction to release the residual stress. Measurements of the subsequent deformation of the ring in the circumferential and radial directions

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