The Influence of Cyclic Thermal Loads on the Load Capacity of Cylindrical Adhesive Joints

SUMMARY

Cylindrical adhesive joints are more and more often used as construction nodes in machines and devices. One of the uses of this type of adhesive joints is composite support overhead insulators, in which fittings made of aluminum alloy with a core made of epoxy glass are glued. These insulators are loaded with variable mechanical and thermal loads under operating conditions. The results of fatigue tests of composite insulators have been presented in several publications, however the results of strength tests of composite insulators subjected to cyclic temperature changes induced naturally by natural aging or by thermal shocks are very rare.

The aim of the work was to determine the influence of natural and artificial cyclical thermal loads on the strength properties of the cylindrical adhesive joints made of aluminum alloy and epoxy glass composite, modelled on the connection occurring in the construction of the composite support on overhead composite support insulators used in high and very high voltage networks.

The results of research on the influence of cyclic natural thermal loads on the strength properties of cylindrical adhesive joints made of aluminum alloy and epoxy glass composite showed that the seasoning of joints cured at room temperature beginning in summer, after 6 months increased their load capacity by 11,9%, while the seasoning beginning in winter period did not cause significant changes in the load capacity after six months. Extending the seasoning time to one and two years did not cause statistically significant changes in the load-bearing capacity of joints cured at room temperature. On the other hand, the load-bearing capacity of the joints subjected to heat treatment (post-curing), along with the extension of the seasoning time, decreased by 17,4% after six months of seasoning. After one year the decrease was 21,3%, and after two years 23,9%.

The research on the influence of cyclic artificial thermal loads (thermal shocks in the temperature range between -20 ° C and +60 ° C) on the strength properties of cylindrical adhesive joints with a glue joint thickness of 0,025 mm, 0,075 mm and 0,125 mm showed that thermal shocks increase the load capacity by 5,26% ÷ 6,17%. The change in the number of cycles of thermal loads from 50 to 150 cycles did not show statistically significant changes in

the load-bearing capacity of the tested adhesive joints, which was confirmed by the analysis of significant differences made by the t-test.

The experimental tests were supplemented with numerical simulations of the stress state in the glue joint of cylindrical adhesive joints at temperatures of -20 ° C and +60 ° C, which was performed using the Finite Element Method using ABAQUS/Standard software. The simulations carried out have shown that the stress value is influenced by the thickness of the glue joint. For example, the value of radial stress in an adhesive joint with the thickness of 0.025 mm at a temperature of +60 ° C is 4.136 MPa in the edge zone and 5.525 MPa at a temperature of -20 ° C, while in the adhesive joint with the thickness of 0,125 mm, hoop stresses assume the values of 11,939 MPa and 14,691 MPa, respectively. The value of axial stress in the adhesive joint with a thickness of 0,025 mm at the temperature of +60 ° C is -20,898 MPa in the edge zone and -44,421 MPa at the temperature of -20 ° C, whilst in an adhesive joint with a thickness of 0,125 mm, the axial stresses assume the values of -14,009 MPa and -25,255 MPa, respectively.

The conducted research showed the existence of the influence of cyclical natural and artificial thermal loads on the strength properties of cylindrical adhesive joints made of aluminum alloy and epoxy glass composite.