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Fatigue behavior of an insulation system for the ITER magnets

Rainer Prokopec, **Karl Humer,** Harald W. Weber

Atomic Institute of the Austrian Universities, Vienna University of Technology, 1020 Vienna, Austria Stadionallee 2 1020 Vienna Austria

The application of glass-fiber reinforced plastics as insulation materials for fusion magnet coils (e.g. the Toroidal Field Coils of ITER) requires the full characterization of their mechanical performance under ITER-relevant conditions. One of the methods of testing material's response under dynamic load is the tension-tension fatigue procedure. This test can be used to simulate the pulsed tokamak-operation of the ITER coils over a lifetime of more than 20 years. Furthermore, it provides information on the maximum tensile or shear stress in the ITER-relevant range of 104-105 cycles.

In order to simulate the operation conditions of ITER as closely as possible, several fatigue parameters can be set in the test programme, e.g., the minimum-to-peak stress ratio R and the frequency  of the sinusoidal load function. Further, the fatigue process can be run under load or strain control. All of these parameters may influence the mechanical response of the insulation system under cyclic load. Therefore, it is highly desirable to investigate the influence of test parameter variations on the measured stress-lifetime diagrams.

The investigations were performed at 77 K using an industrial glass-fiber reinforced composite impregnated with epoxy resin. For both the load and the strain controlled mode, R-values of 0.3 and 0.5 and a frequency of 10 Hz were chosen.

The results showed almost no deviations in the lifetime behavior between the load and the strain controlled mode, up to the ITER specified number of pulses, i.e. 3x104 cycles. Beyond this point, the residual strength levels were lower by 5-30 % under strain control than under load control. This effect is more pronounced at higher cycle numbers and for lower R-ratios.