Designing of Endturn Corona Protection of Generators By Help of Simulation

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Abstract

As the liberalization of the energy market has been taking place for years, the demand of generators is led into a new stage. Benefiting from the highly efficient gas turbine rated between 100 and 400 MW, the simple, robust and economical air-cooled machines turn to be preferred. On the other side the air cooling, however, limits the stator current. So the modern generators are rated to higher output voltage to improve their overall capacity. Figure 1 depicts the concept of end-winding insulation of a generator bar. To avoid the air gap discharge between the straight part of stator winding and the grounded lamination core, the surface of this straight part was covered with a semi-conductive layer and this layer is extended out of the core for a few centimeters. Stress grading materials, such as silicon carbide (SiC), have been used to control the high electrical field strength at the end of the semi-conductive layer. SiC has a nonlinear electrical conductivity: it is conductive in high field area and insulated in low field vicinity. With this property the high field could be reduced in form of flowing current. This current, on the other hand, heats up the stress grading material and could lead to overheat or even burn-out in the worst case. In this work, simulation tools have been developed to learn the behavior of SiC based stress grading: the performance of field strength reduction and side effect of overheating. Experiments were done to gather the basic information of the nonlinear conductivity. It was found that this field strength dependent value could generally be written like K=A*e^(B*E) where conductivity K (S/m) and field strength E (V/m) are measured. A and B are constants that could be estimated with help of mathematical evaluation of measurements. Two simulation tools with different concepts were developed: 1D circuit model and 2D/3D FEM model. In the circuit model the object was discretized longitudinally into small pieces of segments. Each segment would be simulated with a 'double T Network' (Figure 2). By means of a fine discretization, the potential distribution and heating power would be calculated. It was observed in the experiment with generator bar that the temperature on the bar surface was circumferentially also not even. This effect could not be evaluated with the 1-D network simulation without take great effort. To complement this disadvantage, FEM was used to calculate the heating and the electric field strength distribution in 2D and 3D geometry.

Figures used in the abstract

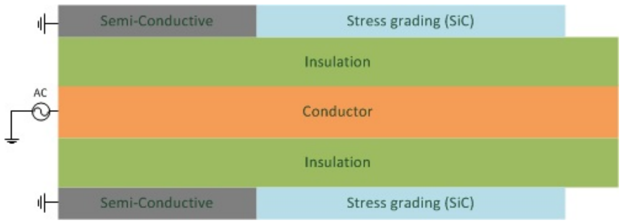

Figure 1: Insulation Arrangement of Endturn in stator winding.

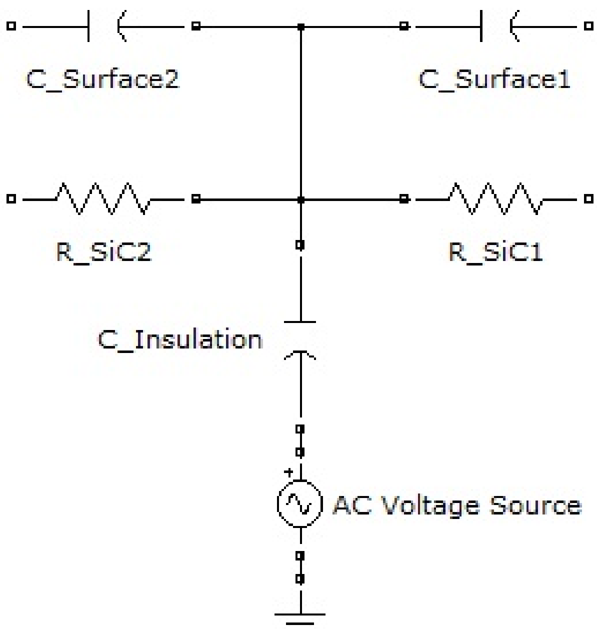

Figure 2: ‘Double T Network’ Model.