Semi-Empirical Measurement of Thermal Conductivity in Carbon Fiber Insulators

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Abstract

Previous experimental work has been conducted to measure the conductivity of FiberForm, a carbon fiber insulator, through the use of a cut-bar metering apparatus. The analysis of these experiments currently relies on 1-D heat transfer assumptions inherent to the cut-bar metering method. A 3-D model of the apparatus has been developed to verify the validity of these assumptions, as well as quantify the experimental uncertainty induced by the assumptions. The expected sources of heat loss in the apparatus are through the natural convective losses from the cut bar, as well as radiation exchange between the cut bar and enclosure walls. The model uses a combination of radiative, convective, and conductive heat transfer models to determine the heat losses from the metering bar, such that these losses can be quantified and used in the analysis of the material thermal conductivity. Experimental conditions were measured so that boundary conditions could be set to replicate the experimental data. Thermocouples were placed on the wall of the enclosure to measure the wall temperature gradient to properly account for radiative exchange. The thermal conductivity for the sample used in the model was defined as the first estimated conductivity from the experimental measurements. Environmental conditions present during the experiments were replicated in the model, such as gaseous composition and pressure. Using the semi-empirical analysis from the 3-D model, a template 2-D model will be developed to account for heat losses in future experimental measurements.