Application of a Random Pore Model for Thermal Oxidation of Nuclear Graphite

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A persistent concern for high-temperature applications of synthetic graphite material is loss of graphite due to thermal oxidation gasification reactions with O2, H2O or CO2. In certain conditions, oxidation enlarges the inherent pores in graphite, which rapidly degrades microstructure and properties. Oxidation weight loss behavior can vary significantly among grades of nuclear graphite, for example, which have different microstructures due to differences in raw materials and processing. However, there are currently no validated oxidation models in use that predict oxidation rates from initial microstructure and inherent material reactivity.

This work presents a new model for isothermal kinetically-controlled oxidation of high-purity synthetic graphite. The model assumes graphite is a binary structure composed of solid graphite and pores, in which the pores are randomly-placed equisized spheres. Spheres growth at a temperature-dependent rate that can be constant throughout the sample or a function of depth. Samples are assumed to be cubes or cylinders, accordingly, the model predicts the effect of changing sample geometry or size on apparent weight loss behavior.

This work will present model predictions versus air oxidation data for five different grades of nuclear graphite that span three orders of magnitude in size and either cube or cylindrical geometry. Model predictions generally bound the experimental data. Once model parameters are known for a grade, predictions can be made for different sample size, geometries, temperatures, and oxidation times.