Creep Deformation Behavior of Heating Filaments in High Temperature Applications

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Abstract

In high temperature applications, e.g., in furnaces for sintering refractory metals or growing single crystals, resistive heating filaments made of refractory metals are widely-used. At temperatures which are usually above 2000°C the heating filaments are exposed to stresses resulting from mechanical constraints and electromagnetically induced Lorentz forces. The lifetime of such filaments is often limited by creep deformations which can in the worst case lead to a short circuit between neighboring filaments or filaments and other furnace components, respectively. To this end predicting the time-dependent creep deformation behavior of heating filaments is an important part already during the development of new heaters. With the aid of COMSOL Multiphysics software, the electromagnetically induced Lorentz forces are computed for different shapes and arrangements of heating filaments. Subsequently, the Lorentz forces are used in mechanical analyses to predict the stresses and the creep deformation of the heating filaments. The creep deformation behavior is accounted for by a creep model for refractory metals presented in [Valentini 2015].

The comparative study shows that the Lorentz forces acting on the heating filaments and the resulting creep induced deformations, respectively, can be reduced by using specific shapes and arrangements of heating filaments.

The AC/DC Module is used for computing the electromagnetically induced Lorentz forces acting on the heating filaments. Subsequently, these forces are coupled to a three-dimensional model of the heating filaments. The time-dependent creep behavior of the heating filaments is computed by using the Structural Mechanics Module with a user defined creep model for refractory metals presented in [Valentini 2015].

Reference

[Valentini 2015] B. Valentini et. al.: Finite element analysis of the high-temperature creep deformation of a TZM heavy duty charge carrier. International Journal of Refractory Metals and Hard Materials, 2015, in press.

Figures used in the abstract

Figure 1

Figure 2

Figure 3

Figure 4