Optimization of Firing Processes of Ceramics using Thermal Analysis Methods and Kinetic Modelling

J. Janoschek, J. Blumm, E. Moukhina, NETZSCH-Gerätebau GmbH, D-95100 Selb, Germany

In the production of ceramics, a green body is frequently manufactured of ceramic powder and additives (binder, sintering aids). This material is then shaped into a green body. The green body is converted into the final product through thermal treatment at high temperatures. The temperature program during the firing process, especially during the binder burnout and in the sintering phase, has a lasting effect on the subsequent characteristics of the product. Optimization of the temperature program during firing and to shorten the duration in the kiln will increase productivity and reduce production costs. Thermophysical properties like density change, specific heat and heat transfer have to be known. Pushrod dilatometers have been used for decades to investigate length changes of ceramics during sintering. Thermogravimetric measurements can be used to analyze the binder burnout and decomposition reactions. Differential Scanning Calorimetry (DSC) can be used to measure the specific heat and enthalpy changes. Laser flash method is well-established for determination of the thermal diffusivity. By combining the results of all measurement methods, it is possible to determine the thermal conductivity of the material and to predict the temperature gradients in ceramic parts by employing finite element simulations. Measurements on Zirconia with the different methods will be shown as example.

Using measurement results achieved at different heating rates and an applying advanced thermokinetic analysis software (NETZSCH KineticsNeo), one can analyze the kinetics of the binder burnout and sintering processes. Understanding the reaction processes allow modelling of the temperature profile for various scenarios. Examples will be presented showing optimized temperature programs shortening the firing time.