Temperature and stress simulation in ceramic bodies during heating and cooling

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During heating and cooling of ceramic materials several different changes can take place depending on the materials' type and composition. These changes can be analyzed with methods of thermal analysis and are dependent in part on severe volume changes, which lead to internal thermal stresses in the material matrix. These internal stresses lead to cracking and ultimately to destruction of the material. This means that during the baking process the material must be slowly heated through the critical temperature regions or held at critical temperatures for a period of time. In regions where transformations do not take place the material can be heated or cooled at a higher rate.

The baking process of ceramic materials is therefore very time consuming, energy intensive, and not very flexible and requires expensive tunnel kiln furnaces. An express baking technique that overcomes these disadvantges for ceramic materials was developed.

Through the calculation of the temperature distribution and the resulting thermal stresses the critical temperature regions for heating and cooling of ceramic materials can be determined which allows for an optimization of the baking process. This leads to considerable time, energy and cost savings.

The temperature and stress fields are determined with a specially designed finite element method [FEM]. As prerequisite for an FEM simulation are measurements with methods of thermal analysis and precise determination of the thermal physical properties of the ceramic material dependent on the temperature in a respective state during heating and cooling. The dimension of the body also has to be taken into consideration.

Temperature and stress simulation results for a ceramic material during heating and cooling are presented.