Modelling Of A Sintering Furnace Using COMSOL Multiphysics®

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Abstract

Sintering is an essential process in the consolidation of powdered materials, enabling the transformation of compacted powders into dense, solid structures through controlled heating and atmosphere. Operating below the melting point of the base material, without any forces applied for a natural sintering, this multidisciplinary process is widely used particularly for ceramics. The studied furnace is not only a sintering furnace, but also the site of a uranium oxide conversion reaction, occurring in the pre-sintering zone. The simulation of this process using COMSOL Multiphysics®, provides insights into improving industrial sintering efficiency and product quality.

The model aims to study the influence of thermal and atmospheric conditions, as well as geometry on sintering quality. The walking beam furnace is loaded with boats containing pellets, in which heat transfer, chemical reaction, densification, and stress evolution are simulated. During all the process, thermal radiation is applied at the boundaries, while conduction and natural convection govern internal heat exchange. In the pre-sintering zone, a chemical reaction occurs. Dihydrogen gas is injected to react with uranium sesquioxide present in a small fraction, converting it into uranium dioxide phase present in the powder. This temperature dependent reaction also generates water vapor. Densification is modelled through an analytical law dependent on temperature, relative density, and shrinkage rate, with local stresses estimated using a densification-dependent expansion coefficient.

This model provides detailed predictions of temperature fields and how the reaction depends on both temperature and the availability of dihydrogen. Chemical reaction duration is predicted as well as the amount of H_2O produced during the conversion. It also sheds light on stress distributions, supporting high product quality. This tool enables the execution of sensitivity studies aimed at optimizing process parameters, thereby enhancing the quality, efficiency, and productivity of the process.

Figures used in the abstract

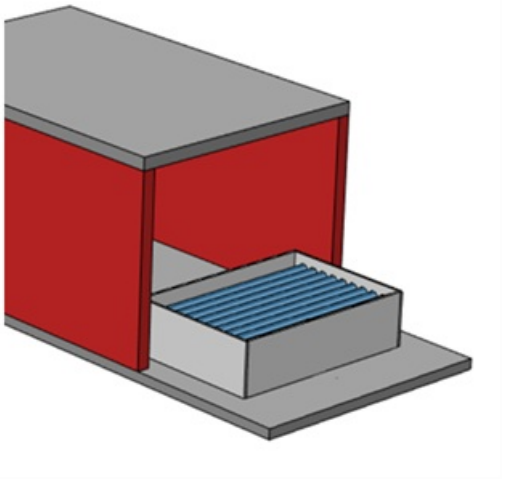

Figure 1 : 3D representation of a part of the sintering furnace, with one boat filled with pellets.