SUCCESS STORY

K1-MET SusMet4Planet Competence Center of Sustainable Digitalized Metallurgy for a Climate Neutral and Resource Efficient Planet

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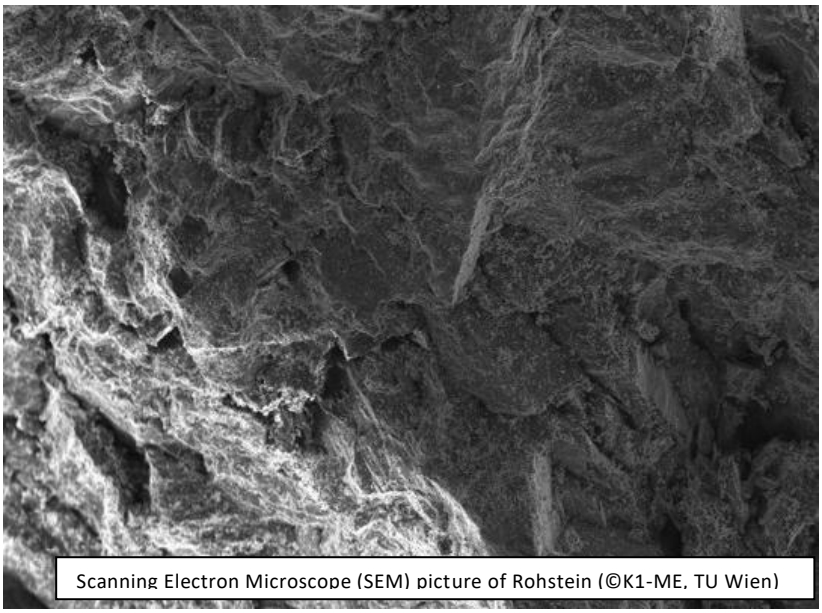

Scanning Electron Microscope (SEM) picture of Rohstein (©K1-ME, TU Wien)

INDUSTRIAL-SCALE CALCINATION & SINTERING – A NOVEL MACRO TGA SUPPORTS MODEL DEVELOPMENT

AN INTEGRATED APPROACH COMBINING EXPERIMENTS AND SIMULATIONS TO OPTIMIZE INDUSTRIAL CALCINATION AND SINTERING

Thermogravimetric analysis (TGA) is a widely used technique for investigating material behaviour under controlled temperature profiles and defined gas atmospheres. Based on TGA measurements, valuable insights into reaction kinetics can be obtained. Conventional TGA systems are typically designed to investigate small, homogeneous samples in the milligram range, enabling detailed analysis of intrinsic reaction kinetics, thermal degradation processes, and the material stability of fine particles.

However, the use of very small sample sizes limits the representation of processes relevant to industrial-scale operations. In particular, phenomena such as heat and mass transfer limitations, internal temperature gradients, and structural or morphological evolution during processing are not adequately captured. Bridging this gap between laboratory-scale investigations and industrial reality represents a key challenge.

This challenge has been addressed through the development, construction, and commissioning of a novel MacroTGA system. The system enables thermogravimetric analysis under extreme conditions, including high temperatures and large sample sizes. Its key features include:

- Operation at temperatures of up to 1800 °C
- Analysis of large samples of up to 500 g and 10 cm in diameter
- Controlled gas atmospheres (N_2, O_2, CO_2)

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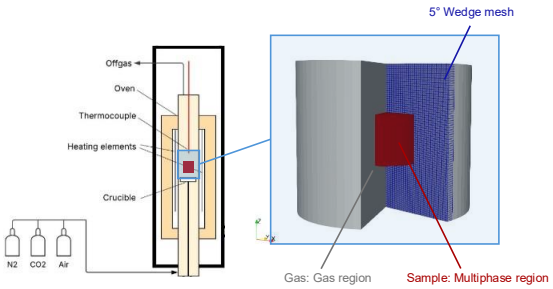
- High-precision, continuous mass measurement

This unique setup provides new opportunities to investigate thermal material behaviour under conditions that closely resemble industrial practice. It is particularly valuable for studying industrial-scale calcination and sintering processes. In rotary kilns, raw materials are exposed to temperatures of up to 1800 °C and typically have particle sizes in the centimetre range. Under these conditions, thermal gradients as well as heat and mass transfer phenomena, and heterogeneous reactions play a dominant role.

The experimental results obtained with the Macro-TGA directly inform the development of a detailed CFD-based calcination and sintering model. This model captures decomposition processes during calcination as well as morphological changes during calcination and sintering, including shrinkage and porosity evolution.



Left: Scheme of high-temperature MacroTGA oven; right: CFD simulation mesh of sample in MacroTGA (©K1-MET, TU Wien)

Impact and effects

The integrated approach - combining experimental data from the novel MacroTGA with advanced modelling - enables unprecedented insight into material behaviour inside rotary kilns, which are otherwise difficult or impossible to access. The detailed calcination and sintering model enables the development of advanced process models that can be embedded into large-scale rotary kiln simulations.

The resulting modelling framework is a powerful tool for exploring new pathways to optimise refractory production. It supports process design choices and contributes to the development of reduced-emission production routes.

Project coordination (Story)
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Project partner

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- RHI Magnesita GmbH, AT

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