Drying of dense monolithic refractory materials

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Purpose:
Dense monolithic refractory castables are used in the steel industry as lining material in steel transfer and teeming ladles, in tundishes, blast furnace runners and as steel mill accessory parts. The drying of these monolithic refractory materials is complicated due to their high densities and low porosities. The micro pore structure and many capillaries hinder the release of steam resulting in a pressure increase within the material, especially at high drying speeds. This can result in cracking or even worse to an explosion.

These materials are difficult to properly dry with the typical drying techniques resulting in long drying durations and high rejection rates.

Several alternative drying techniques, such as microwave drying, promise advantages in this special drying problem. The effects of microwave drying and hybrid microwave-electric- drying on the drying behavior of monolithic refractory castables are therefore examined.

The microwave heating is quite different than conventional electric resistance heating. It is expected that this will have an effect on the drying of castables. With conventional methods of heating heat is transferred via convection and radiation to the body and from the surface via conduction to the middle of the body. Because most castables have low thermal conductivities this process takes a long time. Microwave heating on the other hand heats the whole body uniformly. Only on the surface will the body cool because the microwave do not heat the air surrounding the body. With microwave heating the core of the body has the highest temperature as aposed to electric heating where the highest temperature is on the surface.

Experimentation:
For the experiments, two types of castables with distinctly different properties have been chosen: a castable with a high cement content [HCC: High Cement Castables] and a thixotropic castable with extremely low cement content [ULCC: Ultra Low Cement Castables]. From both materials sample bodies have been produced with weights between 10 kg and 30 kg.
Before experimentation the properties of both materials are determined with the methods of thermal analysis (TG: Thermal Gravimetry and DTA: Differential Thermal Analysis.)
A hybrid-microwave furnace has been constructed and tested.

Results:
The results of experiments, so far, show that microwave drying of monolithic refractory castables is possible. The drying curve of the microwave drying is similar to the drying curve of conventional drying, which can show with the TG-analysis.
With high microwave power or hybrid heating the maximal drying rate can be reached. This allows for determination of the necessary microwave power and possibly the electric resistant heating power. This could lead to a more economic drying process with the advantages of hybrid-microwave.