Thermochemical Calculations Applied to High Temperature Corrosion of Ceramic and Refractory Materials

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Abstract

Ceramic materials, in particular refractories, find applications under oftentimes extreme operating conditions like high temperatures and pressures as well as oxidative, reducing and corrosive atmospheres. Beside gas phase corrosion this also includes corrosion reactions at the direct contact of different ceramic materials as well as ceramic materials in contact with glasses, metals and alloys and also with metallic-, oxide-, silicate- or salt-melts.

In combination with corrosion experiments and standardised test methods for refractories and refractory materials available at the Department of Mineral Engineering thermochemical calculations provide information about phase-stabilities and -compatibilities, phase- and decomposition-reactions, solubility in liquid phases, solid solution formation etc. and by this way contribute to the prediction and analysis of corrosion processes as well as their prevention by selection of suitable materials under given process conditions. Application limits can be defined for specific materials and in some cases high temperature processes must be optimized to reduce corrosion processes by the determination of relevant process parameters.

In the presentation different examples for the application of thermochemical calculations to high temperature corrosion of ceramic and refractory materials using the FactSage software and the corresponding experimental results from current projects at the Department of Mineral Engineering will be given.

Examples for gas phase corrosion are the corrosion of refractory materials under oxyfuel atmospheres and the selection of stable ceramic materials for the thermal partial oxidation of liquid hydrocarbons with changing oxidizing and reducing

atmospheres. Thermodynamic calculations on the slag-refractory interaction of commercial and laboratory grade refractory materials will be discussed for the conditions of pressurized coal combustion to clarify corrosion mechanisms like the dissolution and re-precipitation of sesquioxides and spinels and to make suggestions for a suitable materials selection. One of the current fields of interest in contact-corrosion between ceramic materials and alloys is the application of ceramic materials as promising tool materials for the shaping of semi-solid alloys, especially for the thixoforming of high melting point alloys like Cu-alloys and steels. For the development of ceramic tool materials interface-reactions at the ceramic/metal contact have been investigated by corrosion tests and accompanied by thermochemical calculations that for example demonstrate the strong influence of the oxygen partial pressure on the corrosion reactions between ceramics and alloys and also very complex phase reactions between the alloying elements and the ceramic oxides. Finally, one example for the adaptation of existing thermodynamic datasets to new experimental results will be shown in case of zircon ($ZrSiO_4$) based materials, that have a wide range of application as construction material in glass tanks, in iron and steel production, in energy technology, as moulds and cores in precision investment casting or as protective coatings of steel-moulding.