Prediction of the Volatile Recirculation in Cement Rotary Kilns by Means of Process Simulation

Robert Emler
Chair of Ceramics, University of Leoben, Leoben, Austria

ABSTRACT

A variety of influences contributes to wear of refractories in cement rotary kilns and cause a chemical, mechanical and thermal loading of the lining. Only the chemical aspect and its impact on the brick lining of the rotary kiln itself shall be considered here, especially the action of alkali salts (sulphates, chlorides). A decisive parameter for refractory wear is the degree of sulfatisation DS which may be expressed as the molar ratio of sulfate and chlorine to alkalies:

The following wear mechanisms may e.g. occur in dependence of DS: For DS > 1 a sulfate corrosion of the lime content of the binder phase of basic refractories, especially dicalcium silicate, may be expected. For DS < 1 e.g. the formation of alkali chromate sulfates may happen in the case of magnesia chromite refractories and may lead to wear of the chromite component. In the case of DS = 1 salt infiltration is expected to behave chemically inert, but salt melts migrate into the bricks and fill up the pores until they solidify.

When the lining is cooled in the case of a shutdown the infiltrated part of the brick behaves more brittle and spalling may occur especially at the border between infiltrated and uninfiltrated part. Alkali salts are mainly accumulated by an evaporation/condensation process interacting between the kiln atmosphere and the kiln feed, and are infiltrated into the bricks by condensation from the vapour phase. The considerations quoted above show the importance to control this process and to know about its influence on the amount of alkalies and the composition of alkali salts condensed. In many cases it is desirable to predict the loading of refractories by alkali salts in dependence of varying process parameters. Especially changes of fuel are of great importance nowadays. Introduction of petrol coke may significantly rise the sulfur input, polymers may contain chlorine. A prediction of the volatile recirculation caused by a change of the fuel may e.g. help to optimize refractory selection and estimate the impact of process technology on wear.

To fulfill this goal calculation of volatile recirculation is performed by means of process simulation. For this purpose a total process model has been established. Commercial software packages FactSage™ and SimuSage™ have been used and linked with Borland Delphi™. For simulation purposes reactors are defined to model all elementary process steps, e.g. the preheater stages and the calciner. The rotary kiln as well as the cooler is discretised into several sections, each of them represented by a reactor. These reactors establish balances governing mass and heat transfer, and enable the calculation of chemical equilibrium. The total of these balances sets up a nonlinear system of simultaneous equations which is solved by a numerical iteration procedure. As a result, the chemical composition of all solid and gaseous mass fluxes is available. In combination with a thermal simulation of the kiln lining the infiltration of alkali salts into the refractory may be calculated additionally.