Thermochemical Characterization of the Gas Circulation in the Relevant Cement Industry Processes

This work focused on the thermochemical characterization of the gas circulation in the cement kiln and was undertaken due to the real industry problems during clinker production. Raw materials and fuels used for clinker production contain significant amounts of sulphates, chlorides, alkali, alkali earth compounds as well as heavy metal compounds. These substances can react upon technological conditions, giving volatile species that vaporize completely and subsequently condense in colder reactor part. Simultaneously, raw materials flow continuously introduced into reactor causes secondary steering of volatile species to the high temperature reactor area. In this way, the evaporation/condensation cycle of volatile species produced in the technological regime takes place, leading to unsteady kiln operation, increased refractory consumption and clinker quality, clogging and finally the necessity of production breaks aimed in the reactor cleaning from substances deposed at its walls.

The aim of the investigation was a better understanding of the volatile cycles in cement production technology by studying the thermodynamics of gas-gas and gas-solid reactions between chemicals occurring in the cement kiln, focused mostly on alkali sulphates vaporization. The studies were carried out mainly by the unique technique Knudsen effusion mass spectrometry.

First part of the project was the investigation of pure sulphate compounds, Na$_2$SO$_4$, K$_2$SO$_4$ and CaSO$_4$ and the quasi binary system Na$_2$SO$_4$ – CaSO$_4$, K$_2$SO$_4$ – CaSO$_4$. By renewed pure alkali sulphates vaporization the thermodynamic characteristic of pure sulphates was determined and the fragmentation path of the gaseous species explained. The results are in agreement with the literature data. In the renewed investigation of K$_2$SO$_4$ – CaSO$_4$ system the activities of the compounds were obtained with the higher accuracy. By the measurement of Na$_2$SO$_4$ – CaSO$_4$ system, the activities of Na$_2$SO$_4$ were obtained by Na$_2$SO$_4$ – rich samples. The second part of the project was the determination of volatiles over the samples taken directly from the kiln from four different cement plants. The industrial materials were collected from four different cement plants, at four different kiln stages to characterize the dependence of volatiles vaporization on various parameters such as atmospheres and temperature.