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Kinetics of iron(III) oxide interaction with $NaCl–H_2SO_4–H_2O$ solutions

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Abstract

Studies of the kinetics of the interaction of iron(III) oxide powder with $NaCl–H_2SO_4–H_2O$ solutions were performed using a thermographic method modified by us in relation to the task. The unit is used to record the temperature in the reactor with an accuracy of 0.1 ^oC with a frequency of 5 s and record the signal to the computer in the form of a graph in the coordinates "temperature–time", as well as in a tabular form. The composition of the solutions was changed in the range of total ($NaCl+H_2SO_4$) concentrations from 0.1 to 2.0 mol/l and within the interval the concentration of H_2SO_4 was changed from 0 to 2 mol/l. Of the two possible reactions, the reaction with the formation of iron(III) sulfate is thermodynamically preferable to the formation of iron chloride(III). At the initial volume of the solution of 100 ml, the amount of iron(III) oxide corresponded to the reaction with the formation of sulfate, and the amount of oxide was administered with an excess of 20 mol %. The experiments were carried out at initial solution temperatures in the reactor equal to 26.0, 33.0, 41.5 and 46.8 ^oC. Subsequent analyses of the solution composition and measurement data were used for material and thermal balances. Based on the heat balance performed the determination of the kinetic equation by analyzing the curves of the "temperature-time". It is found that the increasing part of the curve in the region from the initial to the maximum temperature is approximated by a polynomial of 3 degree, and the falling part of the curve is linear. By mathematical processing of both parts of the graph, the dependences of the rate of transformation on the composition of the solution and the temperature are obtained. It is also determined that the type of speed dependence on the degree of transformation does not meet the known kinetic models of heterogeneous processes. It was found that due to exothermicity, the average speed of the process is controlled by a mixed mode: kinetics on the surface of the oxide particle and convective heat exchange. On the basis of studies, kinetic parameters are established: the velocity constant equal to $1.353 \cdot 10^2$ mol/s, the order of H_2SO_4 concentration in the solution equal to 1.0647, the activation energy equal to 123.44 kJ/mol and the dependence of the velocity on the degree of transformation in the form of a graph determining the deviation from the kinetic model of the compressing nucleus.

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