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REDUCTION OF IRON OXIDES IN BAUXITE BY HYDROGEN

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ABSTRACT

Dehydration of bauxite and reduction by hydrogen of iron oxides present in Gove Bauxite have been investigated isothermally and in dynamic conditions. Experimental methods applied provided the possibility for calculating the amount of water formed during the reduction in the presence of water evolved from not completely dehydrated bauxite. A relationship was found between the dehydration temperature and the time for dynamic and isothermal conditions, respectively. When the temperature of bauxite dehydration decreases, the temperature at which the reduction is complete falls considerably.

INTRODUCTION

One of the methods for removing of iron from bauxite consists in reduction by hydrogen of iron oxides present in the raw material. This process is preceded by dehydration of bauxite. Removal of all of the water from bauxite requires heating to temperatures above 1273 K at which the surface area (ref.1) decreases considerably. On the other hand, if the process of dehydration is not complete, the results of the investigations of the reduction are disturbed by the fact, that the water removed from the sample originates from two reactions. For the investigation of the relation between temperature of dehydration and the rate of the reduction, the method should be applied. It provides the possibility for calculating the amount of water formed during the reduction in the presence of water evolved from not completely dehydrated bauxite.

EXPERIMENTAL PROCEDURE AND RESULTS

The Gove Bauxite has been investigated with the following amount of the main components: Al_2O_3-51.4%, Fe_2O_3-17.0%, and H_2O-26.7%. Dehydration and reduction experiments have been carried out on the Mettler 2000C thermoanalyser. The flowrate of nitrogen or hydrogen was 40 cm^3min^{-1} and the heating rate was $10Kmin^{-1}$

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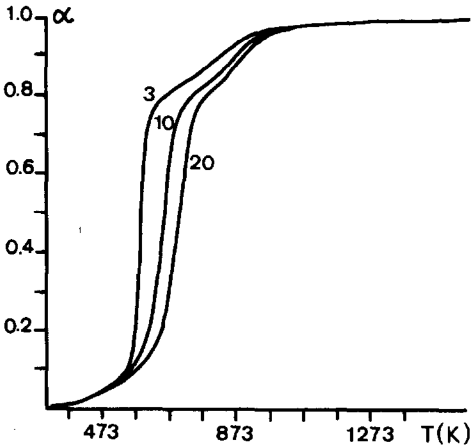

Fig.1. Extent of bauxite dehydration α at different heating rates (3-20Kmin^{-1})

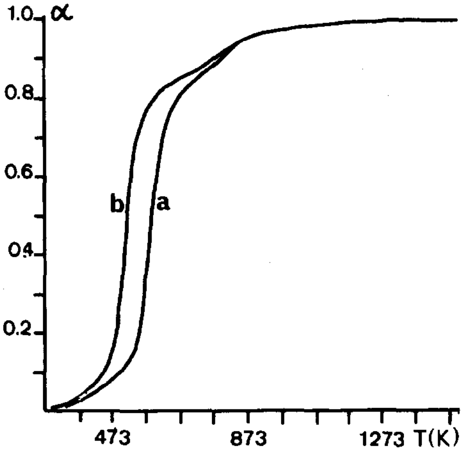

Fig.2. Dehydration of bauxite under atm. pressure (a) and vacuum 50Pa (b). Heating rate 5Kmin^{-1}.

(for some experiments heating rate was changed in the range 3-20Kmin^{-1}). The sample weight was about 30 mg and in some dehydration experiments approximately 150 mg.

In order to check the influence of the experimental conditions on the dehydration process, experiments with different heating rates have been made. The results show (see fig. 1) that the last step - in which about 5% of all water is removed - does not depend on the heating rate. In order to test if it is possible to remove the water totally at lower temperatures - to prevent the sintering of samples - experiments under vacuum (50 Pa) have been carried out. Even at these conditions, lowering of the temperature of the total bauxite dehydration was impossible (see fig. 2). In this situation it is necessary to estimate how much water still remains in the bauxite when dehydration occurs at the temperatures lower than 1473K and to find an experimental method, which permits for the kinetic calculations of reduction for not fully dehydrated samples.

The experiments for bauxite dehydration under different temperatures have been carried out isothermally on Mettler 2000C thermoanalyser. Bauxite samples were heated very fast (5-6 min.) from the room temperature to the temperature of dehydration and then were kept isothermally 30 minutes. After this time, the temperature in the system was increased to 1473 K and the samples were heated till loss of weight was not observed. The ratio between weight loss after 30 min. of isothermal dehydration to the total weight loss (the average value 26.7%) gave the percentage of water still present in bauxite after dehydration. The results of these investigations are listed in the table 1.

TABLE 1

The percent of the total amount of the water removed from bauxite after 30 min. of dehydration at the temperature T

T(K)	873	923	973	1023	1073	1173	1273	1373
%	96.7	97.2	97.7	98.1	98.5	99.1	99.5	99.8

The theoretical weight loss in the reduction by hydrogen of iron oxides present in bauxite (ref.2) is 13.20%. For Gove bauxite 17.0% is Fe_2O_3 and the corresponding stoichiometric loss of the weight due to reduction is 5.11% of the weight of the reactant. Comparing these values with the results from Table 1, one can calculate, that for bauxite dehydrated at the temperatures 1000-1100K the amount of water evolved from not completely dehydrates samples is on the order of 10% of the total weight loss during reduction.

To investigate the relation between temperature of dehydration and temperature of the reduction following method has been applied: samples were heated with the rate $30Kmin^{-1}$ to the temperature of dehydration and then they were kept 30 minutes at this temperature. After fast cooling to the room temperature and filling the system by hydrogen, the temperature was increased with the a rate of $10Kmin^{-1}$ up to 1273K. The weight loss recorded during heating under hydrogen was the sum of the water produced in the reduction and the water released from not completely dehydrated bauxite.

The second run with the new sample were performed at exactly the same conditions, but all experiments have been carried out in nitrogen atmosphere. The difference between two TG curves recorded under hydrogen and nitrogen gave the weight loss only due to reduction of iron oxides. Experimental results agree well with stoichiometric calculations, in all experiments the total weight loss for the reduction was in the range ±1% of theoretical value.

A great influence of dehydration temperature on the rate of iron oxides reduction was observed. The relationship between the progress of the reduction and temperature for experiments made in dynamic conditions is shown on the fig.3. Reported in the literature (ref.2) are data for the reduction temperature of iron oxides present in bauxite and these are much higher than obtained in present paper. To check if it is possible to make a reduction at a temperature as low as 880K, isothermal experiments have been undertaken. They have been performed generally in the same way as those at dynamic conditions, but the last part of each run has been made isothermally at 880K. The results of isothermal reductions are shown on the fig.4.

Both dynamic and isothermal investigations show,that decreasing the tempera-

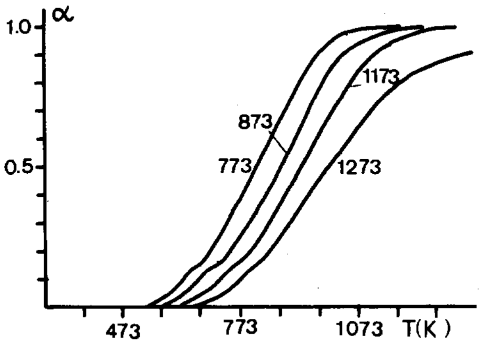

Fig.3. Progress of the iron oxides reduction for bauxite dehydrated at different temperatures (temp. of dehydration are shown on the curves)

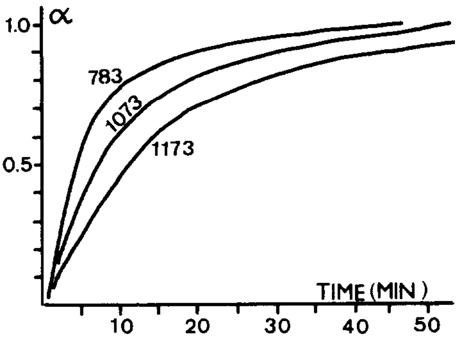

Fig.4. Isothermal reduction at 880K of the iron oxides in bauxite (temp. of dehydration are shown on the curves).

ture of the bauxite dehydration leads to higher activity of the bauxite in the reduction process. Dehydration of bauxite in high temperatures leads to sintering of reactants and consequently to the decrease of the surface area. Lowering of the dehydration temperature to 800-900K shortens time and reduces the temperature of the reduction.

The method used can be useful in all investigations of solid-gas reactions in the case where two reactions occur simultaneously. Through the change of the experimental conditions there is the possibility to separate these processes.

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