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High Temperature Sintering Kinetics of α-Al_2O_3 Powder

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Abstract: *The sintering kinetics of α-Al_2O_3 powder is investigated in this paper. Commercial α-Al_2O_3 powdered compacts were sintered close to 95 % of the theoretical density. The characteristic parameters of sintering kinetics were also determined.*
Keywords: *Alumina; Sintering.*

Резюме: *В данной работе исследовали кинетику спекания α-Al_2O_3 порошка. Прессовки коммерческого α-Al_2O_3 спекали почти до 95 % теоретической плотности. Определены характерные параматры кинетики спекания.*
Ключевые слова: *Глинозём; спекание.*

Садржај: *У овом раду проучена је кинетика синтеровања α-Al_2O_3 праха. Испресци комерцијалног α-Al_2O_3 синтеровани су до близу 95 % теоријске густине. Такође су одређени карактеристични параметри кинетике синтеровања.*
Кључне речи: *Алумина; синтеровање.*

1. Introduction

Alumina (α-Al_2O_3) is one of the most examined materials [1]. Generally, fundamental investigations of sintering kinetics and mechanism of α-Al_2O_3 powder are most important in the physics of sintering.

The results recorded by measuring the shrinkage rate of the pressed samples of α-Al_2O_3 powder are frequently used in examinations of the sintering kinetics of this material [2-5]. These results showed that sintering of α-Al_2O_3 is controlled by grain-boundary diffusion in the initial stage. The change of activation energy during non-isothermal sintering of α-Al_2O_3 is in detail examined using the data obtained, which is used to calculate the apparent diffusion coefficient [6]. Experimental results of sintering highly sinterable α-Al_2O_3 showed that grain-boundary diffusion is the predominant mechanism [7].

In this work we examined the kinetics of high-temperature sintering of α-Al_2O_3 using the relationship between linear shrinkage and the sintering time. The characteristic parameters of this process were defined, too.

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2. Experimental Procedure

Commercial α-Al_2O_3 was used in this work. The powder contained 0.78 % impurities including 0.42 % SiO_2, 0.21 % MgO and 0.15 % CaO. The average size of particle was 1.2 μm. The powder was pressed under the high pressure of 1 t/cm^2 and we obtained compacts whose density was 1.73 g/cm^3. Sintering was carried out in the temperature interval between 1823-1973 K for 15-480 min. The density of sintered samples is shown in Tab. I.

Tab. I The density of sintered α-Al_2O_3 samples

t (min)	ρ_s (g/cm^3)			
	1823 K	1873 K	1923 K	1973 K
15	3.01	3.11	3.40	3.53
60	3.13	3.27	3.47	3.55
120	3.20	3.38	3.50	3.61
240	3.31	3.45	3.56	3.65
480	3.51	3.59	3.64	3.70

The density of the green compact (ρ_0) and those of isothermally sintered compacts (ρ_s) were calculated from dimensions and weights.

3. Discussion

In this work examinations of sintering kinetics of α-Al_2O_3 were performed in the temperature range typical for the final sintering stage. A logistic curve was obtained after 15 min. of sintering, while a practically linear dependence was obtained after 480 min. (Fig. 1). According to the results obtained we can see that maximal densities of the compacts are approached after 480 min.

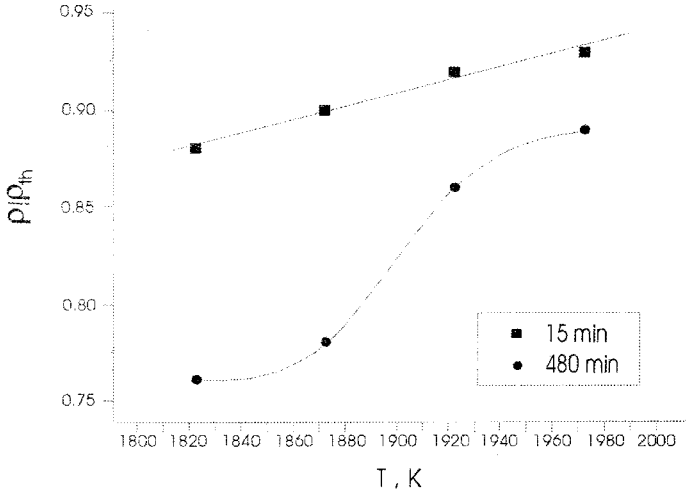

Fig. 1 Relative density as a function of the sintering temperature.

Lee et al. [8] determined the relationship between linear shrinkage α-Al_2O_3 and sintering temperature under conventional sintering conditions. They concluded that below 1673 K linear shrinkage is very small. Our results indicate that shrinkage, in the temperature interval of 1823-1973 K, is 17-22 %.

For sintering time less than 60 min. (Fig. 2), the kinetics of that process can be described by the following equation:

$$n = dt/t \Big/ d\left(\Delta L/L_0\right),$$

where t is the sintering time and $\Delta L/L_0$ is the relative linear shrinkage. For our conditions n = 1.

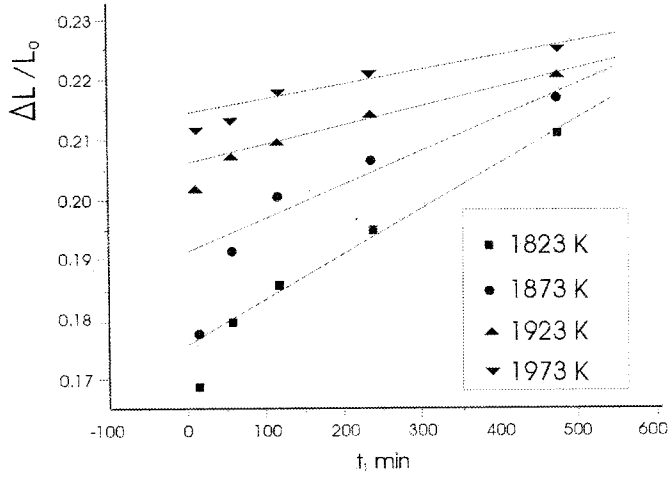

Fig. 2 Linear shrinkage of the specimen as a function of the sintering time.

Using the formal sintering rate, the activation energy of the high-temperature process of sintering α-Al_2O_3 samples (Fig. 3) was calculated and its value is 240 $kJmol^{-1}K^{-1}$.

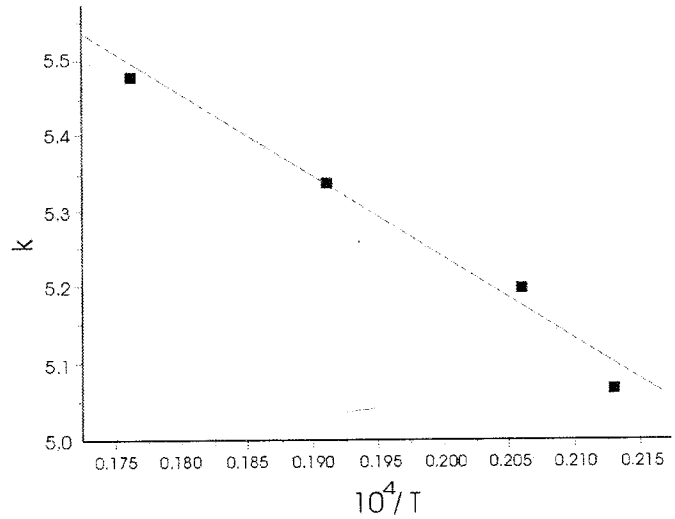

Fig. 3 The sintering rate constant as a function of the sintering temperature.

4. Summary

A study of conventional sintering of α-Al_2O_3 powder compacts (1823-1973 K) showed that the samples could reach approximately 95 % of the theoretical density at the temperature of 1973 K. At all used temperatures, for sintering times below 60 min., a linear dependence quantitavely describes the linear process of sintering. In this case, the activation energy of the sintering process is 240 $kJmol^{-1}K^{-1}$.

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