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A POSSIBILITY TO DECREASE THE SINTERING TEMPERATURE OF CORUNDUM CERAMICS

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ABSTRACT

The ceramics consisting of more than 95%Al_2O_3 is called corundum ceramics. The name comes from the name of the α-crystalline form of the aluminum oxide - corundum.

The basic technological process influencing the properties of this ceramic is the temperature and the duration of the sintering process. Sintering aids are used to improve sintering and to control grain size.

The possibility to use $CaTiO_3$ as sintering aid is investigated. This substance lowers the sintering temperature with more than 100^{o}C and at the same time the mechanical properties are preserved. The compressive strength is more than 2000 MPa and the flexural strength is more than 200 MPa.

KEYWORDS: alumina, sintering temperature, corundum, calcium titanate

1. Introduction

The ceramics consisting mainly of Al_2O_3 is called corundum ceramics after the name of the α-form of alumina - corundum. This ceramics must contain more than 95% Al_2O_3 and the main crystalline phase has to be corundum [1]. The corundum ceramics possesses a series of valuable properties and for this reason it is widely applied.

The sintering of the corundum ceramics is the basic technological process influencing its properties. The sintering is carried out at relatively high temperatures – 1600-1750^{o}C. Corundum is difficult to be sintered.

The diffusion mechanism as well as the recrystallization process depends on temperature and time of exposure at high temperature, the grain size and crystalline condition of the row material, the initial density of the sample [2].

The presence of specially introduced additions exerts a particular influence on the sintering temperature and the grain size and from there on the properties of the final product.

2. Results and discussion

The alumina ceramic must have a fine grain polycrystalline structure consisting mainly of α-Al_2O_3 (corundum). This microstructure is essential for the mechanical properties of the ceramic components. The increase of the grain size decreases the strength of the material. Sintering additions are used to improve sintering and to control grain size. The possibilities to use $CaTiO_3$ as sintering additions are investigated. $CaTiO_3$ is added to Al_2O_3 micrometric size powder in quantity of 3, 6 and 9 weight %. Samples are fabricated by pressing and sintering at different temperatures. The apparent density, the compressive and bending strength in relation with the sintering temperature are determined.

It is interesting to evaluate whether a high content (up to 10%) of $CaTiO_3$ will lower considerably the sintering temperature and at the same time will preserve the high mechanical properties of the corundum ceramics. The mechanical properties versus the sintering temperature and the quantity of the sintering additions are studied. The average values of the compressive strength depending on the $CaTiO_3$ content and the temperature of the heat treatment are given in Table 1.

Table 1. *Compressive strength in MPa of samples with different $CaTiO_3$ contents and sintered at different temperatures*

Sintering temperature, ^oC	**$CaTiO_3$ 3 wt %**	**$CaTiO_3$ 6 wt %**	**$CaTiO_3$ 9 wt %**
1580	1932.4	906.5	475.0
1630	1456.6	743.5	392.1
1680	1134.1	557.6	321.1

An increase of the $CaTiO_3$ content and the sintering temperature is detrimental for the mechanical characteristics of the composite material on Al_2O_3 basis (fig.1 and fig.2).

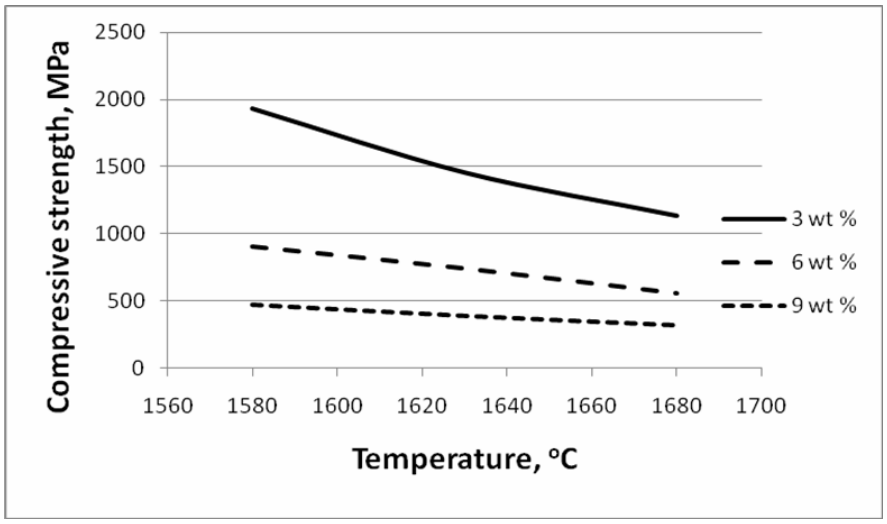

Fig. 1. *The compressive strengh in relation with the sintering temperature.*

As per our previous research [3] part of the calcium titanate reacts with the alumina and is converted into $CaO.6Al_2O_3$ – β-alumina. The higher the temperature and the $CaTiO_3$ content more β-alumina is obtained. According to Buchvarov [2] the presence of β-alumina is not favourable for the mechanical characteristics of the ceramic on Al_2O_3 basis.

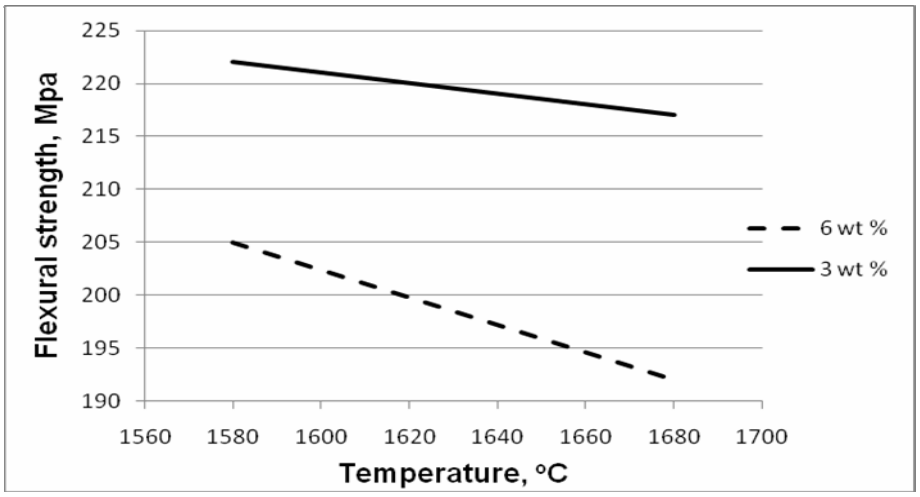

Fig.2*. The bending strength in relation with the sintering temperature.*

The maximum quantity of $CaTiO_3$ which has to be added as sintering additions is 3 %. We made a detailed study on the sintering temperature (Fig. 3). The maximum density of 3930 kg/m^3 is achieved at a

sintering temperature of 1600^{o}C. When the compressive strength at different sintering temperatures is determined, a similar relation is achieved (Fig. 4).

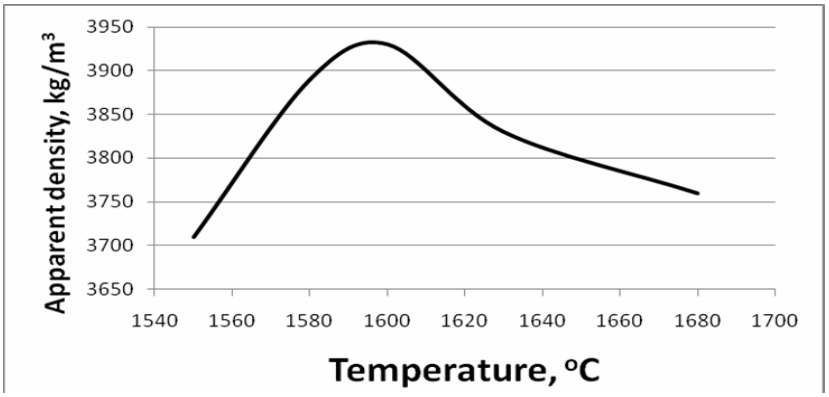

Fig.3. *The apparent density in relation with the sintering temperature ($CaTiO_3$ – 3 wt.%).*

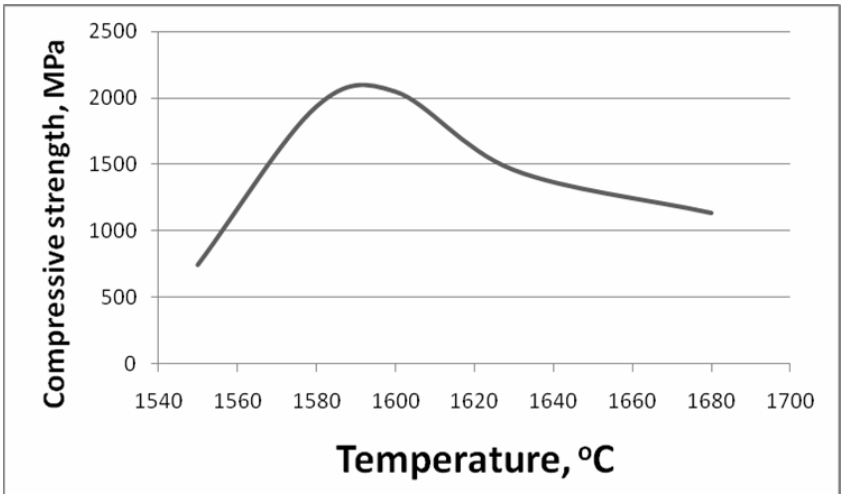

Fig.4*. The compressive strength in relation with the sintering temperature ($CaTiO_3$ – 3 wt.%)*

3. Conclusions

Calcium titanate can be used as sintering additions for ceramic on Al_2O_3 basis.

During the temperature treatment part of the $CaTiO_3$ reacts with the alumina and is converted into $CaO.6Al_2O_3$ – β-alumina. The presence of β-alumina is not favourable for the mechanical characteristics of ceramic on Al_2O_3 basis. The content of $CaTiO_3$ must not exceed 3 weight % in alumina based ceramic.

The sintering temperature of ceramic on Al_2O_3 basis containing $CaTiO_3$ should not be higher than 1600^{o}C. Samples with 3 wt. % $CaTiO_3$ as sintering additions and sintered at 1600^{o}C possess compressive strength of 2100 MPa and flexural strength of 220 MPa.

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