Microwave Sintering of Fly Ash Substituted Body and Numerical Analysis

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Abstract

Fly ash 70wt% contained green bodies were sintered by using a 2.45 Ghz microwave oven and their properties were investigated. Samples were sintered at 1,150℃ and kept at that temperature up to 50 minutes by 10 minutes intervals. Numerical analysis on the microwave heated system was carried out in order to figure out the heat transfer phenomena in the cavity.

1. Introduction

Microwave processing is one of new processing methods in ceramic materials and has advantages such as fast firing, selective heating, heating from inside of a sample and cost savings, etc..[1-3]. The sample was heated with SiC as a suscepting material by using a microwave hybrid heating(MHH) method since most oxide ceramic materials absorb microwave energy a little at low temperature. This SiC susceptor absorbs the microwave energy and heats up very fast. The sample itself absorbs the microwave energy and converts it to heat effectively after the temperature passes the critical temperature(Tc). The effective dielectric loss factor of the sample becomes high as the temperature goes up by the radiating heat from the susceptor.

2. Experimental Procedures

The fly ash was mixed with clay as a 30:70 weight percent ratio and the detailed procedure to make the greenbody was published in reference 1. The density of the slurry to make the greenbody was 1.6.

A simple 2.45 Ghz kitchen model microwave oven(LG Electronics,: Model MR-M274, 750W) was used in this experiment. Temperature was increased by 40℃/min up to 1,150 ℃ which was decided from the previous experiment with a conventional electric furnace and kept at that temperature from 10 minutes to 50 minutes by 10 minute intervals. Temperature increments of the susceptor and the sample were measured simultaneously to find out the critical temperature(Tc) up to 1,150 ℃.

3. Results and Discussion

SEM investigation revealed that necking had been progressed in the sample as time passed by and pores became smaller. However, the compressive strengths did not change much among the sintered samples and the average compressive strength was 1,200 Kg/cm^2 . The bulk densities of the sintered samples showed a slight increment as increasing time.

Fast heating in microwave heated system is one of the major advantages. In order to investigate the heating effects of the susceptor and the substituted body, a numerical analysis on the microwave heated system was made. Though direct comparisons are not available, it could give qualitative explanations about the heating mechanism.

From the result of temperature distributions in the microwave heated system, one can figure out how heat sources were applied on the sample. It is understood that heat was generated at the location of SiC susceptor inside the cavity in the microwave heating system and the susceptor showed very concentrated temperature profiles blocked by the Isolite insulating brick. Heat generated at the susceptor propagates heat from inside of the susceptor to outward. Eight minutes after putting input power of 750 watts and it went up to 1100 ℃ within 30 minutes. From the results, one can conclude in the calculation that microwave heating could be an effective way for sintering in fly ash system.

4. Conclusion

1) Sintering of fly ash mixed with clay as 70:30 weight percent ratio was done successfully by using microwave energy and necking had progressed as sintering time increased from 10 minutes to 50 minutes at 1,150 ℃.
2) Numerical analysis of heat transfer can be an effective method to verify the heat distribution in the cavity during the microwave sintering process.

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5. References

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