Literature Reviews

Example from Engineering

2.5 Benefits of Rapid Heating

specific focus of this section of literature review

One of the chief advantages of microwave heating which is commonly cited is the rapid heating rates which can be achieved, and the resultant reduction in grain size of the sintered compact. Other techniques for rapid heating of ceramics have also been studied**.** Heating rates The effects of heating rate on the densification of alumina - titanium carbide composites using a resistance heated dilatometer, for example, was investigated by Borom and Lee[89], ranging from 20 to 400^0C/min were used. It was found that up to approximately 1500^0C the diffusion kinetics were such that the final density was independent of the heating rate. However, the density of samples heated to temperatures in the 1600 to 1950^0C was a function of the heating rate, with significant increases in density being achieved, even though holding times at the maximum temperature were reduced to as little as 2 minutes. This was largely attributed to the suppression of chemical reactions which normally impede sintering of alumina when carbon is present. Final microstructures were comparable to those achieved by commercial hot-pressing techniques.

1st example of other techniques

2nd example

Zone sintering equipment inductively heated by a radio frequency generator has also been used to rapidly heat alumina and $BaTi0_3$ ceramics. [90,91,92] In both materials, a microstructure was obtained with a finer grain size than was achievable for samples of the same density prepared by conventional sintering. Raymond and Lesley suggest that this occurs because the lattice diffusion coefficient is raised and the surface diffusion coefficients lowered at higher temperatures. These favour densification rather than grain growth.

3rd example

An investigation into the use of rapid plasma sintering for alumina rods, was conducted by Young and McPherson[93. Th] They found extremely high shrinkage rates in the alumina. They claim that shrinkage rates of 1 to 4%ls cannot be explained by isothermal diffusion mechanisms alone, but that localised temperature gradients created during rapid heating act to enhance mass transport. Johnson[94] argues that isothermal sintering models can account for the shrinkage observed during plasma sintering, and that temperature gradients would have no significant effect on densification. Young and McPherson[95] counter these arguments by pointing out errors in the assumptions about grain growth in Johnson's analysis, and clarifying the details of the heat transfer path, which they state that Johnson has oversimplified.

contrary view

counter argument

"Rate controlled sintering"(or "RCS")[97,98,99] is another technique used in the rapid heating of ceramics. This technique has produced samples with small grain size and high density. In this approach, microstructural development is controlled by heating quickly to an intermediate temperature, and then slowly increasing the temperature to the desired maximum. This prolongs the intermediate sintering stage, where most of the densification occurs, and avoids problems of pore entrapment and excessive grain growth. The products are of uniform, small grain size with as high a density as can be produced by using the conventional approach of heating to the maximum temperature, and then holding at that temperature for a prolonged period. RCS has the added advantage of being more energy efficient than conventional methods.

4th example

5th example

The rapid firing technique has also been assessed for use in industrial heating of whiteware. Poppi and Vincenzini[100] found that there were significant gains in energy efficiency and production rates as well as improved material properties achieved by rapid heating, as long as appropriate measures were taken to ensure that temperature gradients within the material were minimised.