



Results & discussion

ENGINEERING EXAMPLE

In this example thesis, the results and discussion sections appear in the same chapter.

Example: discussion section in a thesis (combining Results & Discussion)

Results and Discussion for Samples Sintered in the Commercial Microwave Oven

It was found that high density could be achieved (up to 99.6% of the theoretical density) in the commercial microwave oven. Results for the 3 mol% yttria zirconia powder are summarised below. No experiments were performed with 8 mol% yttria zirconia powder in this oven. Runs 12 and 14 were performed in a conventional electric oven in order to provide some data for comparison.

Table 5a: Properties of Samples Sintered in the Commercial Microwave Oven

| Run No. | Sample Nos. | Average Density (g/cm ³) | MOR (MPa) |
|---------|-------------|--------------------------------------|-----------|
| 3 | T5J6 | 5.91 | *ND |
| 4,5,6 | T7-M | *ND | *ND |
| 7 | T18-T21 | 6.05 | 268 |
| 8 | T22-T25 | 6.04 | 287 |
| 9 | T26-T29 | 6.02 | 240 |
| 10 | T30-T33 | 6.06 | 289 |
| 11 | T34-T37 | 6.03 | 252 |
| 13 | T42-T45 | 5.99 | *ND |
| 15 | T50-T53 | 6.05 | 240 |
| 16 | T54-T57 | 6.01 | *ND |
| 17 | T58-T61 | 6.04 | *ND |
| 18,19 | T62-T69 | 6.03 | *ND |
| 20 | T70-73 | 6.07 | 197 |
| 21 | T74-T77 | 6.08 | 203 |
| 23,24 | T82-T89 | 6.08 | 300 |

results

*ND = not determined due to some defect in the sample (eg cracked or bowed).

Table 5b: Properties of Samples Sintered in an Electric Furnace

| Run No. | Sample Nos. | Average Density (g/cm ³) | MOR (MPa) |
|---------|-------------|--------------------------------------|-----------|
| 12 | T38-41 | -6.02 | 268 |
| 14 | T46-49 | 6.03 | 287 |

compares density results achieved in microwave and conventional sintering

SEM studies showed that the typical grain size for samples sintered in the microwave oven was approximately 0.2 to 0.3 μm, as compared to a grain size of approximately 0.5 μm for the same powder sintered to a similar density in the electric furnace. Prolonged sintering in the microwave oven did result in grain growth, with an average grain size of up to approximately 0.8 μm being achieved. A typical microstructure of a microwave sintered sample is shown in Figure 24.

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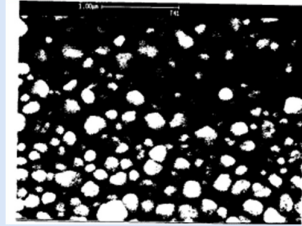


Figure 24: Typical microstructure of samples sintered in the commercial microwave oven.

Examination of the cross sections of a number samples revealed that some contained regions of significantly lower density in the centre. It is thought that this may indicate that these samples were at least partially sintered by heat transfer from a plasma or from the susceptors, rather than by direct coupling with the microwave field. Strengths were very variable, with average figures somewhat lower than samples sintered conventionally to a similar density. However, lack of reliable information about the temperatures experienced by the samples, and doubts about the source of heat energy causing sintering during these experiments made any detailed comparisons impossible. General information about load size, sample arrangement, temperature measurement, susceptor and insulation requirements gained from this initial work were very valuable in designing and establishing the sintering technique used in the custom built microwave unit. All further results reported are from work performed in the custom built unit.

discussion

5.0 Experimental Results for Samples Sintered in the Custom Built Microwave Oven

5.1 Density

5.1.1 Density as a Function of Temperature

Density was found to increase with temperature for both heating methods (see Figures 25 to 28). At low temperatures, the density of the microwave samples was significantly higher than that of the conventionally sintered samples; but the difference in density decreased as temperature increased for both 3 and 8 mol% yttria materials. The difference in densities was also reduced at the higher heating rate; for example, the difference between microwave heated and conventionally heated 3 mol% yttria zirconia, heated at 20°C/min, was within the range of experimental error even at 1300°C, the lowest temperature used in the original experimental plan. This difference between the microwave and conventionally sintered samples increased to a significant difference in additional sintering runs performed at even lower temperatures of 1100°C and 1200°C. (Figure 29 shows some of the sintered samples).

Data are listed in Appendix I.

[figure]

Figure 25: Density of 3 mol% yttria zirconia as a function of temperature, with a heating rate of 2°C/min.

presents results only in these sections;

Interpretation and discussion of results then presented in Section 6 of the chapter