Effect of Yield Strength and Morphology of Spray-dried Al_2O_3/15v/o ZrO_2 Granules on the Compaction Behaviour

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1. Introduction

The densification of Al_2O_3/15v/o ZrO_2 (Zirconia Toughened Alumina : ZTA) to the 99% of theoretical density was attempted by controlling the processing parameters affecting the each processing step *i.e.*, milling, spray-drying, forming and pressureless sintering. The ZTA processed under the identical conditions showed a large variation in the green and sintered densities, and the mechanical properties. The deviation of 4-point bending strength was more than 100MPa for the ZTA with ~99% of theoretical density. Moreover, the relative green and sintered densities were deviated greatly from the average value. This low reproducibility could be caused by the variation of spray-dried granule properties. Thus, the effect of yield strength and morphology of spray-dried ZTA granule on the green and sintered densities and the mechanical properties needs to be studied in detail. The objective of this work is to find out the optimum condition of compaction pressure and compaction method depending on the properties of spray-dried granules.

2. Result and Discussion

The flow chart of experimental procedure for this study was given in Fig. 1. The two different spray-dried granules were prepared by adding 5w/o PVA binder. *i.e.*, the granule with 0.5w/o PVA binder and with no binder. The properties of ZTA slurry prior to spray-drying were summarized in Table 1.

The mean particle size of the binder contained slurry after 24 hrs milling was slightly larger than that of no binder slurry (A). The morphology of spray-dried granules was different significantly as shown Fig. 2. The shape, granule size and degree of hollow existing in the granule were analysed using Image Analyzer as given Table 2. The average granule size of the binder contained one was larger than granule A. In addition, almost all of B granule contained the hollow within each granule. Note that the spray-dried granule were stored in the constant relative humidity of 50% for 72 hrs before compaction to keep the consistency of moisture content.

The dependence of green density on the compaction pressure from 800 kgf/㎠ to 1000 kgf/㎠ with 100 kgf/㎠ increment was represented in Fig. 3. The relative green density increased from 56% to 62% for A granule while increasing the pressure to 100 kgf/㎠ above which the lamination occurred. The green density of B granule increased continuously without showing any lamination effect up to 1200 kgf/㎠. The granule A contained more moisture than B. The larger the content of moisture, the higher the deformability during compaction. In addition, the B granule containing PVA binder could cause higher yield stress of granule. The higher yield stress and more brittle behavior of B granule led to the disintegration of granule during high pressure compaction. The high plasticity due to the moisture content and no binder of A granule caused the deformation of granule as shown in Fig. 4(A) rather than disintegration shown in Fig. 4(B). The sintered density of ZTA depending on uniaxial compaction pressure and subsequent cold isostatic pressing was shown in Fig. 5. The deviation of sintered density was reduced significantly by cold isostatic pressing while comparing the deviation of sintered body compacted only using uniaxial press. The sintered density of ZTA was determined by the pressure of C. I. P. as shown is Fig. 5.

3. Conclusion

The dependence of green and sintered densities of Zirconia-Toughened Alumina(ZTA: Al_2O_3 / 15v/oZrO_2) on the properties of spray-dried granules was studied thoroughly to establish the optimum processing conditions leading to a high reproducibility in the light of sintered density. The sphericity, mean size, degree of hollow occurrence and moisture content of spray-dried granules were largely different in between the granule contained binder and the ones with no binder. The effect of these differences in the characteristic of granule on the compaction behavior was examined in terms of the compaction pressure from 80 MPa to 120MPa with 10MPa increment and the compaction method, i.e., uniaxial and cold isostatic pressing. This work confirmed that the reproducibility of sintered density caused by the variation of granule property could be improved by the optimization of compaction process. The variation of sintered density was controlled within 1% deviation by compacting the granules under a relatively low pressure of 80MPa in an uniaxial forming and subsequently high cold isostatic pressing at 500MPa.

Reference

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Experimental

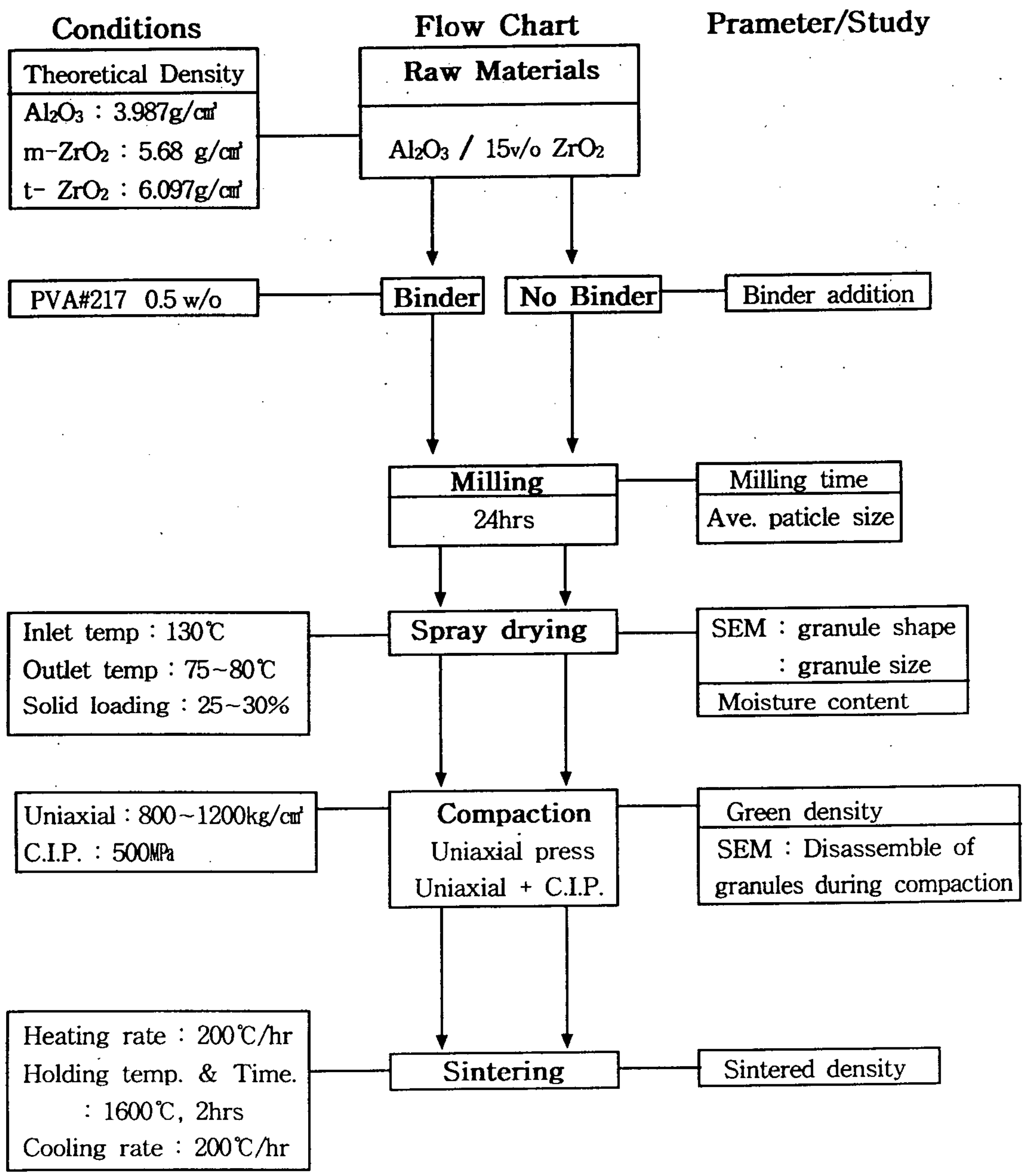

Fig.1 Experimental procedure for the effect of the compaction pressure and compaction method on the green and sintered densities.

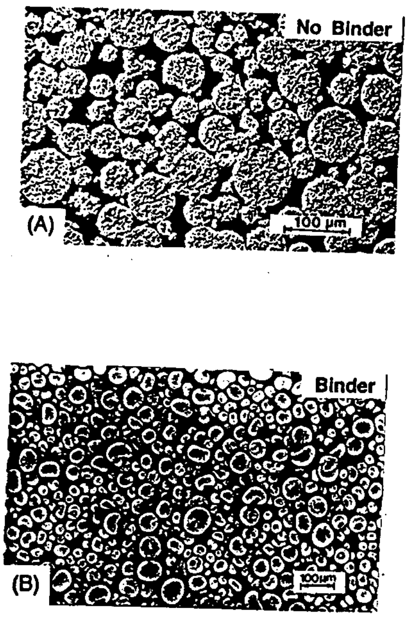

Fig.2 SEM micrographs showing the morphology of spray-dried ZTA granules (A) without binder and (B) with 0.5w/o of PVA 10% solution

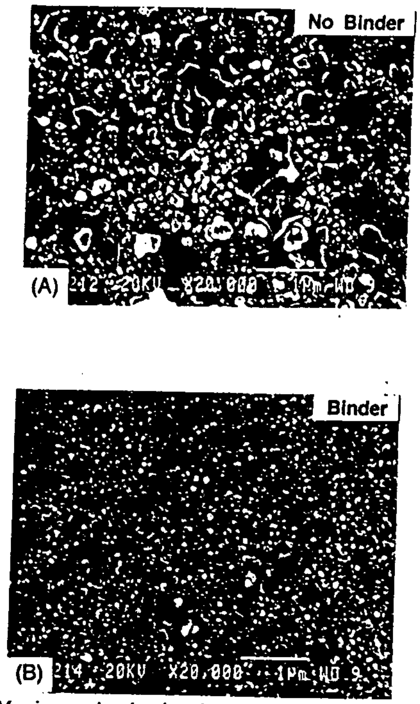

Fig.4 SEM micrographs showing the surface of green body dry-pressed with ~100MPa prior to isostatic-pressing at 500MPa. (A) the granules containing no binder (B) the granules with PVA binder.

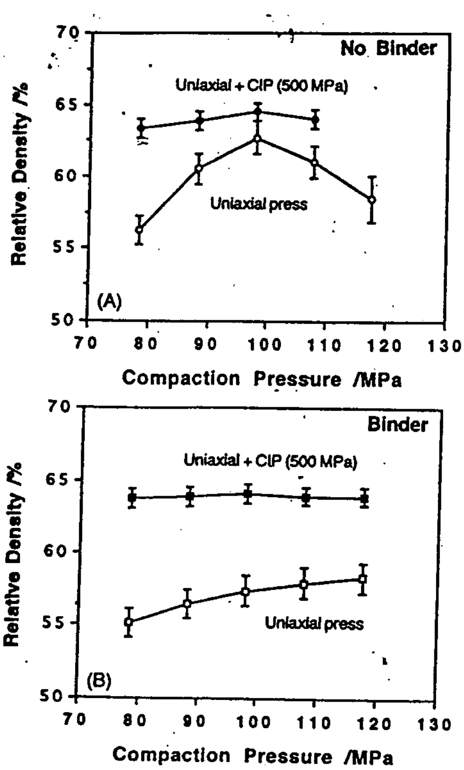

Fig.3 Dependence of the relative compaction density on the compaction pressure and compaction method for (A) the granules containing no binder (B) the granules with PVA binder.

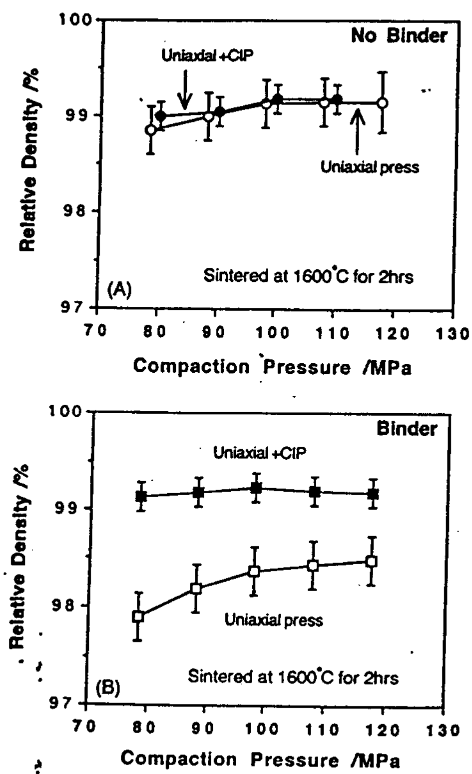

Fig.5 Relative sintered density vs. compaction pressure and compaction method using (A) the granules without binder (B) the granules with PVA binder.