Effect of Sintering Atmosphere on the Scrap Recovery of UO_2+5wt%CeO_2 Pellets

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1. Introduction

Nuclear fuel pellet involves complex phenomena during irradiation in a reactor such as the densification and the swelling. These phenomena depend largely on sintered density and pore size distribution of the pellet [1]. Pellets manufactured by addition of M_3O_8 phase scrap powder can control porosity and density for reducing densification or to make larger grain size for reducing fission gas release [2, 3]. Harada[4] indicated that the densification and grain growth of UO_{2+x} were enhanced by increasing the oxygen partial pressure. In this present work, the effect of M_3O_8 addition on the sintering behavior of UO_2+5wt%CeO_2 is investigated by its addition in the range of 0-50 wt% and by oxidizing step. And these pellets were observed of changes in sintered density and microstructure.

2. Experimental

2.1 Powder Treatments

UO_2 powder used in this work was BNFL IDR UO_2, which has an O/U ratio of 2.11 and an average particle size of 2.2 ㎛. CeO_2 powder, as a surrogate material of PuO_2, has an average particle size of 6.66 ㎛ and a specific surface area of 9.46 m^2/g. M_3O_8 powder was prepared by heating scrap MO_2 pellets in air at 500□ for 5 h. UO_2 and 5wt%CeO_2 mixture is obtained by admixing weighed amounts of the UO_2 and CeO_2 powders in a Turbula mixer for 1h, and then milling for 80 min by using a planetary mill (FRITSCH pulverisette 6). M_3O_8 scrap powder was admixed to UO_2+5wt%CeO_2 matrix powder up to 50wt% by either mixing or milling. In the milling method, scrap powder and matrix powder were mixed and then milled altogether. In the mixing, the weighed amount of scrap powder was added to the matrix powder, which was milled by using the planetary mill and then mixed together by using the Turbula mixer for 1h.

2.2 Sintering

The powder mixture was pressed with a compaction pressure of 300 MPa, by using a double-acting hydraulic press. The diameter and length of the compacts were 10mm and 8mm, and the compacts have green density of 6.1□6.7 g/cm^3. In the conventional single-stage process, the compacts were heated at heating rate of 3□/min and then held at 1700□ for 4 h in a reducing atmosphere of H_2. The three-stage process used in this work was carried out in H_2 atmosphere to setting temperatures (800-1400□) and then changed H_2 atmosphere to CO_2 gas for 2 h during heating up. The density of the pellets was measured by the liquid immersion method. The average grain size on the polished and chemically etched surface was determined using the linear intercept method.

2. Results

Properties of MO_2 powder treated with milling and mixing methods is shown in Fig. 1. Surface area of MO_2 powder treated with milling and mixing methods is decreased with increasing M_3O_8 addition amount. Particle size is about 0.4 um without scrap.

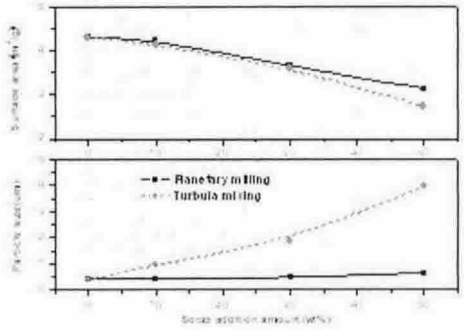

Fig. 1 Properties of MO_2 powder treated with milling method and mixing method

The density variations of MO_2 pellets sintered at 1700℃ for 4 hours with different atmosphere control and admixing methods are shown in Fig. 2.

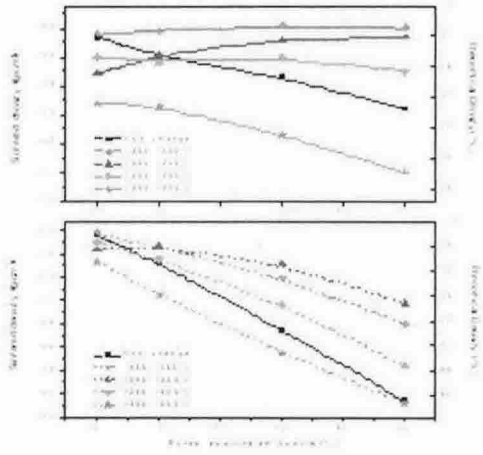

Fig. 2 Density variation of MO_2 pellets sintered with different sintering atmospheres at 1700℃ for 4 hours with a) milling method and b) mixing method.

As shown in Fig. 2(a), the density of sintered pellets sintered with milling method was regularly decreased with increasing the amount of scrap addition in the case of oxidizing step between 1400 ℃and 1600 ℃and non-oxidizing step. But the sintered density of pellets in the case of oxidizing step below 1400□ was almost not changed with increasing the amount of scrap. As shown in Fig. 2(b), the density of pellets sintered with mixing methods was regularly decreased with increasing the amount of scrap addition. The density differences of pellets in the identical condition were greatly increased with increasing scrap amount.

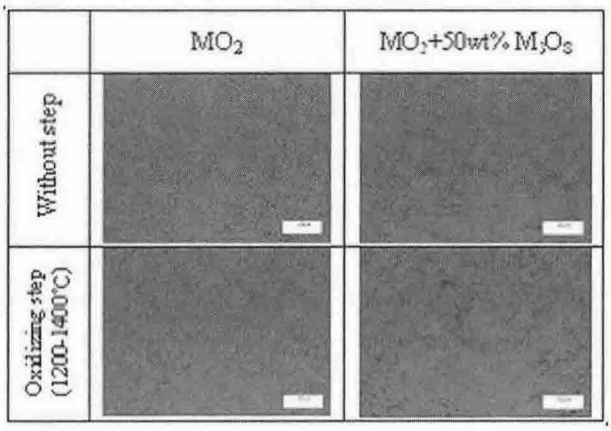

Fig. 3 Microstructures of MO_2 and MO_2+50wt% M_3O_8 pellets sintered at 1500□ for 4 h in the H_2 atmosphere.

The microstructures of sintered MO_2 pellets with oxidizing step and admixing methods are shown in Fig. 3. The grain size for the pellets without scrap was about two times larger than that of the pellets added with 50wt% scrap. The grain size of MO_2 pellets sintered with oxidizing step between 1200 ℃and 1400 ℃were larger than in other sintering conditions used in this work.

3. Conclusion

The surface area of MO_2 powder treated with milling and mixing methods is decreased with increasing M_3O_8 addition amount. The density of pellets sintered with milling method was little changed and that of mixing method was regularly decreased with increasing the amount of scrap addition. The grain size of MO_2 pellets sintered with oxidizing step between 1200℃and 1400℃ were larger than in other sintering conditions. Pore and grain structure can be controlled by the addition method of scrap powder and by the control of oxidizing step.

ACKNOWLEDGEMENT

This study was performed under the auspices of the Korea Ministry of Science and Technology.

REFERENCES

[1] H.Assman, H.Stehle, Nucl. Eng. Des., 48(1978) 49-67
[2] M.D.Freghcey, D.W.Brite., J.L.Daniel and P.E.Hart, J. Nucl. Mater., 62(1976) 138-166
[3] D.Vollath, H.Wedemeyer., J. Nucl. Mater., 106(1982) 191-198
[4] Y.Harada., J. Nucl. Mater., 245(1997) 217-223