Densification Enhancement in AUC UO_2 Pellet with High Lubricant Content

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1. Introduction

In a fabrication process of a UO_2 annular pellet, the accuracy and the precision of the pellet dimension is very important. For an improvement of the dimension deviation, the addition of 1.0 wt% zinc stearate was performed in the process. The improvement is to decrease an axial deviation of the diameter in an annular pellet. Lubrication with a suitable lubricant (zinc stearate) reduces a friction between the die wall and the compact[1]. As a result, the in-homogeneity of the density distribution in the compact can be reduced.

However, the sintered density of UO_2 pellets is decreased. The addition of various dopants in UO_2 has been tried as a way to increase the density of UO_2 pellets, without having a higher sintering temperature or a longer sintering time. The effects of some additives on the grain growth and densification have been widely studied.

Some researchers have studied the effects of sintering additives such as Al_2O_3, TiO_2 and Cr_2O_3-SiO_2. Assmann et al. [2] showed that a simply mixed UO_2-Gd_2O_3 powder was able to be sintered up to 95%TD by adding Al_2O_3. It is reported that $Al(OH)_3$ and TiO_2 have a beneficial effect on the densification of the UO_2-Gd_2O_3 pellets [3]. Kim et al. [4] have investigated the role of a composite additive, Cr_2O_3-SiO_2, and they also observed an enhanced densification of the UO_2-Gd_2O_3 pellets. All the above additives increased the sintered density after a final-stage sintering [5].

In order to improve the sintered density drop due to the addition of 1.0 wt% zinc stearate, in this paper, it was described that the effect of TiO_2 as an additive on the sintered density of a UO_2 solid pellet.

2. Experimental and Results

AUC UO_2 powder was mixed with various contents of high purity titania powders for 1 h and 1.0 wt% zinc stearate for 0.5 h in a tumbling mixer. The powder mixture was compacted with a pressure of 460 MPa. The green density was fixed at ~5.9 g/cm^3 to minimize an unexpected effect. The green pellets were sintered at 1730°C for 4 h in flowing H_2 gas. Samples of UO_2 and UO_2 containing 0.05, 0.1, 0.2, and 0.3 wt% TiO_2 were prepared.

The density of the sintered pellet was measured by using an immersion method. Sintered pellets of UO_2 and UO_2 containing TiO_2 were prepared for a metallographic examination by a mounting, grinding, polishing and etching. The density-measured pellet was cut in the axial direction. And then a grinding and polishing process was performed. To observe the grain structure, a thermal etching for the polished samples was carried out at 1250 ºC for 2h in a flowing CO_2 atmosphere. The microstructure of the samples was observed by an optical microscopy. The grain size of the sample was measured by using the linear intercept method.

Figure 1 shows the sintered density of AUC UO_2 pellets as a function of the TiO_2 content.

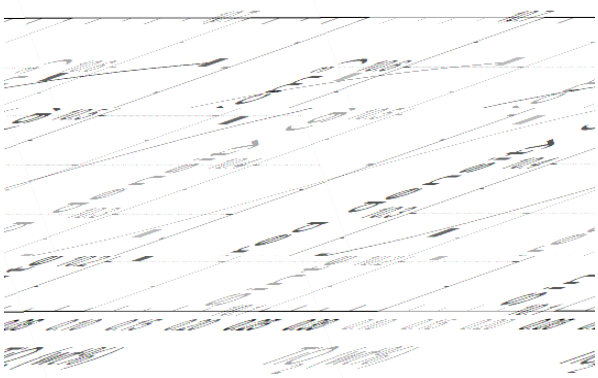

Figure 1. Sintered density of AUC UO_2 pellets with a various TiO_2 content.

It shows that the sintered density increases with an increasing TiO_2 content and it was saturated at ~10.61 g/cm^3. The sintered density of the 0.3 wt% TiO_2 added pellet was increased by more than 0.4 g/cm^3 when compared to undoped UO_2 pellet.

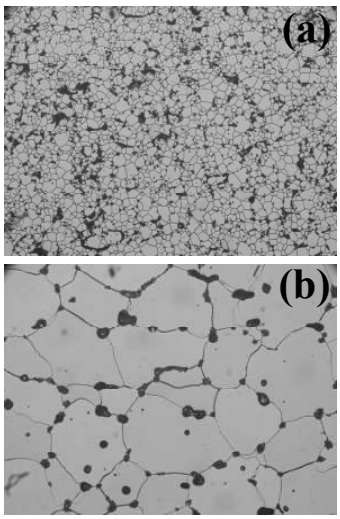

Figure 2. The grain structures of AUC UO_2 pellets (×200); (a) undoped, (b) 0.3 wt% TiO_2

The grain structures of the UO_2 sintered pellet are shown in Figure 2. The grain size of the undoped UO_2 pellet is about 7 μm**.** Those of the TiO_2-doped UO_2 pellets increased with an increasing TiO_2 content. In the case of the 0.3 wt% TiO_2-doped UO_2 pellet, its grain size increased up to about 63 μm. It's rise is nine times as large as the undoped UO_2 pellet. An increasing tendency of the grain size is similar to that of the sintered density. The pores were located at the grain boundary.

Figure 3 shows the pore structures of the UO_2 pellets. A pore of a round shape was formed with an increasing TiO_2 content, and the number of micro-pores was remarkably decreased.

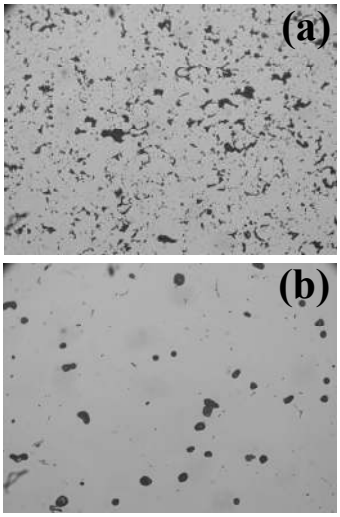

Figure 3. The pore structures of AUC UO_2 pellets (×200); (a) undoped, (b) 0.30 wt% TiO_2

3. Conclusion

In order to improve the sintered density drop due to the addition of 1.0 wt% zinc stearate, the effect of TiO_2 as an additive on the sintered density of a UO_2 solid pellet was investigated.

As a result, the sintered density and grain size increased with an increasing TiO_2 content. In the case of the 0.3 wt% TiO_2-doped UO_2 pellet, the sintered densities and the grain size was increased by up to 10.61 g/cm^3, 63 μm, respectively. A pore of a round shape was formed with an increasing TiO_2 content, and the number of micro-pores was remarkably decreased.

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