The Effect of Pores after a Grinding on the Sintered Density of a UO_2 Pellet

S. H. Na[a], K. H. Kang[a], Y. H. Kim[a], C. J. Park[a], J. H. Yang[a] and M. J. Yoo[b]
[a] *Korea Atomic Energy Research Institute, 150 Deokjin-dong, Yuseong-gu, Daejeon 305-353, Korea, shna@kaeri.re.kr*
[b] *KOREA Nuclear Fuel Company, Ltd., 493 Deokjin-dong, Yuseong-gu, Daejeon 305-353, Korea*

1. Introduction

UO_2 is the most widely used as a nuclear fuel for a current nuclear power generation. The fabrication process of UO_2 pellets is generally similar to a powder metallurgy, that is, powder preparation, compacting, sintering and grinding. Pores are an inherent part of sintering. Accordingly pores are present in the matrix of a UO_2 pellet. The sintered density and the pores of a UO_2 pellet are important factors to assure a stable nuclear reactor control. Because they have large effects on the dimensional behavior of nuclear fuel during an irradiation[1-2].

Pores consist of open pores, which are located on the surface of the pellet, and closed pores, which are located in the matrix of the pellet. It is known that a UO_2 pellet, which has a density of above 96%T.D., has no open pores on the surface of it[3]. After a sintering the sintered pellets, in general, have higher densities than 96%T.D. However, the sintered pellets need a grinding to meet a specification for a diameter because of having a hourglass type after a sintering due to the poor compressibility of the UO_2 powder. Then the pores change from a closed pore to a open pore after a grinding.

In this work, the effect of pores after a grinding on the sintered density of a pellet is investigated. Two conditions-immersed only and immersed and evacuated - are selected to compare the results of the sintered density.

2. Methods and Results

The UO_2 powder was milled by a DM(Dynamic Mill)[4] for 15 minutes to have sintered densities of about 96.5%T.D. The milled powder is compacted to make green pellets with a compaction pressure of 300 MPa. The green pellets are cylindrical type with flat end-faces. Then the green pellets are sintered at a temperature of 1750 ℃ for 12 hrs under a flowing hydrogen atmosphere. And the sintered pellets are ground to have a diameter of 8.12±0.01 mm.

The immersion method(solution is water) is selected to measure the sintered density of the UO_2 pellet.

a) The sintered density as a function of immersed time

The conditions of immersed time are 0(instantaneous after weighing of dry pellet), 24, 48 and 72 hrs. The geometrical density also was measured to compare the immersion density of the pellets after grinding.

Fig. 1 shows the immersion densities of the ground (after grinding) UO_2 pellets with a varying immersed time (not evacuated), based on the geometrical density. As shown in Fig. 1, the immersion density decreases with an increasing immersed time, but above 48 hrs, it increases again. It is considered that the reason for the density decrease is due to the open pores, newly appearing on the surface of a pellet after a grinding. However, the reason for the density re-increasing for a long time (e.g., 72 hrs) is not clear.

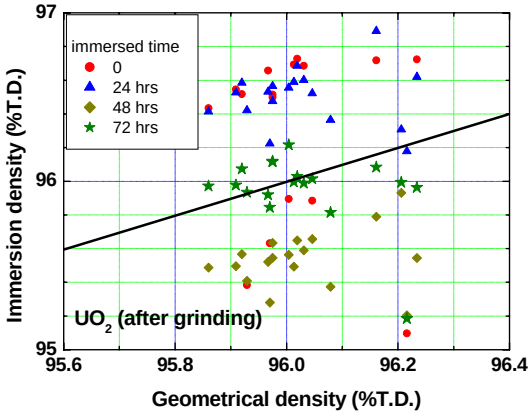

Fig. 1 Immersion density vs. geometrical density

b) The immersion density – before grinding and after grinding.

Fig. 2 shows the immersion density of a sintered pellet (before grinding) and a ground pellet (after grinding). These pellets are evacuated with a vacuum pump. And it also shows the geometrical density for reference. As shown in Fig. 2, the density after a grinding is lower than the density before a grinding. It is thought that the ground pellets have more open pores on the surface of them. But the trend is not linear, because the lower the sintered density, the more the open pores, while above 96%T.D., there is no pore on the surface of a sintered pellet (before grinding). The immersion density difference, $\Delta \rho_{bg-ag}$ between a sintered and ground pellet at 96%T.D. is almost 0.7%T.D. And at a density of 96%T.D. it shows that the immersion density and the geometrical density of

the ground pellets are nearly same. It is considered that the open pores do not affect both of them above 96%T.D.

The density differences, $\Delta \rho_{bg-geo}$ between the immersion densities of the sintered pellets and the geometrical densities of the ground pellets below 96%T.D. are almost the same (=0.7%T.D.). It is considered that the open pores have little effect the geometrical density of the ground pellets.

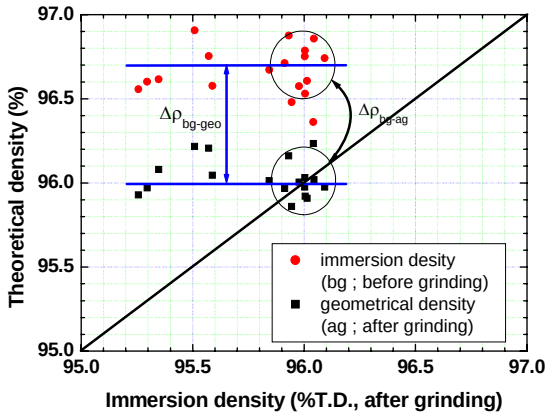

Fig. 2 Immersion density- before/ after grinding

3. Conclusion

- The immersion density decreases with an increasing immersed time up to 48 hrs, and with an increasing immersed time, the density increases again.
- Above 96%T.D, the immersion density and the geometrical density of the ground pellet are nearly the same.
- Below 96%T.D., the immersion density between the sintered pellet and the ground pellet are not linear. And the geometrical density of the ground pellet has little effect on the immersion density of the sintered pellet.

References

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